NATURE AND OUTDOOR LIFE

THE · BOOK · HOUSE ·

A BOOK is just a House of Thought,
Where many Things and People live.
Beyond its doors Great Things are taught,
And all its Dwellers give and give.
So walk right through the open door
With kindly Heart and brain awake.
You'll find in there a Wonder Store
Of Good Things, all for you to take.

The Dwellers in *your* Book House know
All sorts of tales to tell to you,
And each will try his best to show
The way those tales of Wonder grew.
For this our Book House Friends expect
A trifling payment in return;
Just thoughtful Kindness and Respect,—
That's all they *ask* for all we *learn*.

"John-martin"

This BOOK belongs to

THE BOOK TREE

A BOOK TREE is a Knowledge Tree,
As almost anyone can see.
Long, long ago its seed was sown;
For *years* and *years* the Tree has grown.
Ten thousand thousand Hearts & Heads
Have cared for it, so now it spreads
Its Roots and Branches far and wide,
And casts its shade on every side.

This Tree bears Fruit of different kinds
For many Hearts and many Minds.
So all you Children have to do
Is just to take what's *best* for you.
But no one ever soils or breaks
The Golden Fruit he *needs* and takes,
And no one ever bends or tears
The Books this Tree of Knowledge bears.

"John-martin"

A MAY-DAY PARTY.

DRAWN BY C. M. RELVEA.

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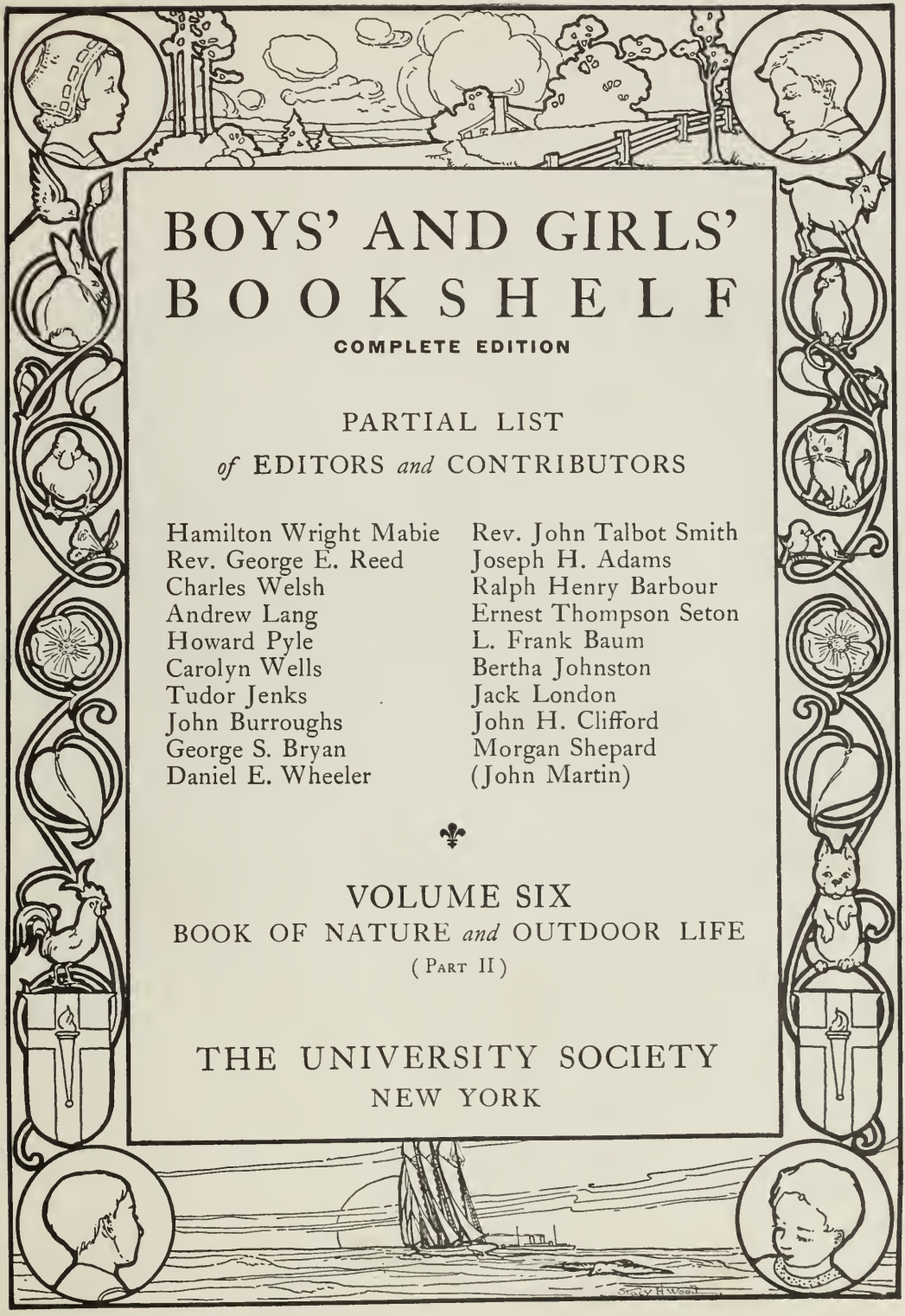

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ANIMAL WAYS AND WHYS

WHY DOES A SQUIRREL BUILD A NEST?

One might answer this question in many ways; but the most satisfactory way will be to go to the root of the matter.

To begin with, by the squirrel we mean especially the common red squirrel, the gay and frisky little animal whose gambols we all love to watch in our woods during the summer. Now leaping from branch to branch, sometimes taking long "headers" into space, yet always landing safely on the desired bough, and now scurrying up the trunk of some giant oak, this little wood-sprite always seems to us to be reveling in the joy of being alive. On the ground, scampering along with tail high in the air and gracefully curled, he seems no less at home.

Now, once on a time, the squirrel—that is to say, the forefathers of the squirrel, or, as some have it, the ancestors of the squirrel—lived entirely on the ground, and in places where trees were, at most, but few and far between. Then they took to frequenting woods, and did a little tree-climbing, becoming as time went on more and more expert, till they gained the skill and confidence we to-day so admire, and I fancy often envy.

This arboreal life—this life in the trees—has become so deeply inrooted in the red squirrel that he loses all sense of security on the ground, as is shown by the fact that when danger threatens he seeks safety, not in hiding among the brushwood, but by bolting up the nearest tree. This being so, it is little likely that when the time for building a nursery comes this will be placed on the ground. No; the kindly spreading arms of some forest giant must provide the place for this; leafy boughs must hide it. The more anxious mother even seeks out the heart of the tree itself—some kindly hollow—where no curious eyes but her own may gaze.

When the site of this nursery is fixed upon, the next step is to fashion it. And this is most cunningly done by interweaving fibers, leaves, and moss to form a nest. As a rule, this nest is placed in the fork of a branch, like a bird's nest; but, as we have said, sometimes a hollow in the trunk of the tree itself is chosen. When the young appear, which is soon after the nest is finished, they are quite blind, helpless, and naked; but they very soon grow into the most delightful and merry little creatures, and gradually learn the art of leaping and all the craft of the woods that a squirrel must know. One would hardly suppose that swimming would be among the things that a squirrel must learn, but this is so, and an uncommonly good swimmer he makes.

A squirrel feeding is always a joy to watch. Sitting up, with arched back, and his long tail gracefully curled behind, he grasps a nut in both hands, and proceeds with his strong teeth to bite off every bit of shell before the delicious kernel is touched. But, once out of its shell, the nut soon disappears. Bark, beechnuts, buds, and the shoots of trees he also eats. We are sorry to have to say it, but he simply cannot resist eggs; and many a poor bird has her nest robbed where squirrels live near at hand. But, worse still: should the nest contain young birds, they too are eaten.

About the habits of the squirrel one might write enough to fill a book. But there are two things worth special mention. In the first place, the squirrel, whatever may be its shortcomings (and we are none of us without some failings), is a most devoted parent. This is shown by the fact that more than one nest is prepared each year, so that if the safety of the young in the first nest is threatened, they can promptly be removed to another at some distance away.

In the next place, we have to speak of the way in which the squirrel passes the winter. In the days of autumn plenty, when nuts abound, a huge store is collected and laid by for winter use. When clouds roll up heavy with snow, the squirrel creeps away to some cozy hole in a tree, and there, snugly tucked away, with his bushy tail curled round him, he falls into a delightful slumber. Should there be a spell of warmer weather, he wakes up, and, after a good stretch, takes a

peep from the doorway of his sleeping-room, and in a moment more is off to his larder for a few good fat nuts. Sometimes he will come forth even when the ground is buried in a mantle of snow.

Before the winter sets in, the squirrel grows a new coat of long fur, nut-brown above, white below. On the tail and the tips of the ears this fur is very long. As the summer advances, the coat is gradually shed, the ears lose their tips and the tail its bushiness, while the upper part of his coat takes on a beautiful warm red color.

Some ground-squirrels—squirrels that live on the ground and do not climb trees—have the fur marked with long stripes of black and white, and these stripes play an important part in rendering the body so marked almost, if not quite, invisible—a very useful provision where enemies of all kinds abound, for a ground-dwelling animal is exposed to more dangers of this sort than a tree-dweller.

For brilliancy of color, and for size, we must turn to India and the Malayan regions, where a coat of bright orange is no uncommon color. Although our squirrel wears two distinct liveries during the year, these are not very conspicuously different in color. One of the Malayan squirrels is of a gray color during most of the year, but when he comes to seek a mate he dons a very striking dress of a bright orange hue! In the matter of size the palm must be given to an East Indian species, which, from the tip of his nose to the tip of his tail, usually measures just three feet four inches long!

Finally, we must not forget to mention one most curious fact about some little striped squirrels found in our own country—the chipmunks. One never thinks of animals as creatures which have pockets of any sort. But this little squirrel is thus provided. And they are to be found in his mouth, each cheek being enlarged to form a pouch! And most useful pockets they are, especially when the winter stores of food are being collected, for then each pocket is crowded till it can hold no more. Then a journey is made to the larder, the pockets are emptied, and a return is made for more. Huge quantities of stores are laid by, distributed among several larders, and when these are full, yet other nuts are hidden under leaves, near the place which has been fixed upon for the winter sleep, which is always in the hole of some great tree-trunk.

WHY DO CATS' EYES ALTER WITH THE LIGHT?

In the eyes of all animals we can generally distinguish, during life, three parts—the outer white portion, the colored portion, and the central portion, which is always black. As a rule, this central black portion, the pupil, is round in shape; but in some animals, as in the horse, it is oblong, and in others slit-like. In the cat the shape of the pupil, as everybody knows, changes from slit-like to round as night advances. Why is this? Though asked in a few words, this question can only be answered at length.

To begin with, the black pupil is the only portion of the eye which is not opaque—that is to say, it is really as transparent as a window-pane, and not solid black, as it appears to be. Let us go into this a little more closely.

The eye, then, you must know, is a hollow ball, filled with a clear fluid, and is divided into a small and a large chamber by means of a circular curtain with a hole in the center, which hole is filled up by a crystal lens, shaped like a magnifying lens. The small chamber is in front, the large chamber behind, this lens and its curtain. The outer wall of the small chamber is formed by the surface of the eye, while the colored curtain, with its central black pupil, forms the inner wall.

But we have just stated that this black pupil is not really black at all! Nor is it. The black appearance is due to the same cause as that which makes the windows of a house look black when seen from the outside. That is to say, when we look at the windows of a house from outside, the room looks dark, full of blackness, so to speak, while from inside the room is really full of light. But the blackness of the window, or pupil, of the eye is deepened by the fact that the walls of the chamber which it lights are covered with an intense black. Beneath this black layer are a number of delicate nerves belonging to the optic nerve, or nerve of sight, while some go to the colored curtain.

Now, sight depends on the stimulating effect of the light which is admitted by the curtain of the eye through the pupil, or lens, to the nerves of sight. Too much light dazzles. So the curtain of the eye, by a wonderful arrangement of muscles, brings its inner rim, or edges, together, so as to make only a very small hole, just as pulling a double string draws up and closes the mouth of a linen bag. When more light is required, the curtain makes a larger window-hole, thereby increasing the size of the pupil. In the cat, when the curtain draws in, it forms a slit instead of a small round hole; when it increases the size of the window, a round pupil results.

Thus, then, by day, when there is much light, the curtain of the cat's eye is kept drawn so as to admit light only through a small crevice—a slit-like window; but as the day declines, and

light grows less and less, the window grows larger and larger. But the same thing happens, of course, many times a day, as pussy runs now out into the sunlight, and now into the room, and again betakes herself to some dark corner to watch a mouse-hole. As the light grows less the slit grows wider, and gradually assumes the form of the great round black pupil.

In very dark places the cat depends more upon his "whiskers" than upon his eyes to tell him in what relation he stands to surrounding objects. For these whiskers—which, we need hardly say, are the long, stiff hairs rooted in the upper lip—are supplied at their base with a very delicate nerve, which responds to the slightest touch.

If the cat were not such a common animal, most of us, probably, would regard it as a much more wonderful creature than we take it to be. Though, like the dog, a flesh-eating animal, it is far more dainty in what it eats, and in a wild state will not eat anything but what it has killed itself. And its ways of killing differ entirely from those of the dog tribe. Dogs chase their prey, if need be, for miles. Cats—and this applies also to all the cat tribe, of which the lion and tiger hold the foremost place—waylay their prey and spring upon it. A cat watching for a mouse differs in no respect, in this particular, from a lion watching for a zebra to come down to the river to drink. Dogs depend entirely on their jaws to hold and disable their prey. Cats, on the other hand, depend very largely on their claws for this purpose. This being so, the claws must be kept sharp, and this could not be done if, as in the dog, they touched the ground with every footstep. To prevent this wearing away by contact with the ground, they are capable of being drawn backward into a sheath. Most of our readers, indeed, must have seen how soon puss's velvet paws can change into very dangerous weapons. Armed with these cruel hooks, cats, both large and small, from the lion downward, grip their victims, and bear them down to earth.

In watching the cat tribe feeding in a menagerie, it is interesting to note that the larger cats hold their food down with their paws while they gnaw off the flesh, and later lick off the last remaining traces of flesh with their great rough tongues, the upper surface of which is covered with long spines pointing toward the throat. The smaller cats have the tongue similarly armed also. Whereas the lion and the tiger hold their food down while they gnaw off the flesh, the smaller cats take the greatest care to avoid soiling their paws, for the fore feet are tucked as far back as possible under the body when feeding. Why this should be we do not know, but so it is.

About the origin of the domesticated cat—the pussy of our firesides—there is some mystery. Some think its ancestor must have been the wild cat, which, even to-day, is found in certain parts of the world; others believe it to be a descendant of the Egyptian wild cat. That is to say, man, in some remote past, caught and tamed wild cats, and from them have descended the domesticated cats of to-day. From these tamed, or, as we say, domesticated cats, a number of distinct races have been reared, such as the beautiful Persian, the blue Carthusian, and the bobtailed Manx cat.

There are some curious facts about the domesticated cat which, so far, have defied all attempts at an explanation. Why, for instance, should all tortoise-shell cats be females? Why is it that white cats with blue eyes are always deaf? But the most puzzling and the most interesting, perhaps, of all these riddles is afforded by the ordinary house-cat. Though few people are aware of the fact, there are two distinct kinds of what we may call tabby-cats. The commonest is that in which the body is of a gray color, marked by narrow bars of black running across the body. This kind very closely resembles the wild cat, which once roamed all over many countries, but now is confined to places in the wilder parts of the earth. The other kind has the black markings arranged after a totally distinct pattern, since, instead of forming narrow bars across the body, the black stripes run along the body, those on the sides taking the form of two curved bars inclosing a shorter bar, giving to the body a heavily blotched appearance. Though various attempts have been made to discover the history of this curious variety, all have failed. We would suggest that our readers should carefully examine the markings of all the cats they meet with, and note to which type they belong.

WHY DOES A CAT ALWAYS FALL ON ITS FEET?

Of course, one answer to this question is that its feet are the best part of it to fall on, but the real puzzle for us is *how* does the cat manage to get its feet lowermost even though it be let fall when it is held by its feet. It has been argued that the cat manages to turn itself by the use of its tail. If that be so, of course, Manx cats, which have no tails, ought not to be able to fall on their feet, but they *are* able. So that that explanation will not do.

All we can say is that somehow, by moving one part of its body on another, the cat controls its fall in order to fall most safely. It is so clever

of the cat that we are not yet clever enough to find out how it does it. But we do know that there was no need to call in the tail as an explanation, for men who jump from great heights or who dive from great heights into water have a good deal of power in controlling their bodies as they fall, though every now and again they make a mistake, and one of them is killed. We should not like to see such feats. And also we hope that you will not, after reading this answer, make experiments on your pussy.

WHY DOES THE GOAT WEAR A BEARD?

Why does the goat wear a beard? Why, indeed! This problem has puzzled many generations of naturalists, and is still unsolved. It is a puzzle, because the goat and the sheep are so closely related that it is often hard to say of certain species that they are more goat than sheep, or more sheep than goat. But sheep never wear beards. If we could say that goats always do, all would be well. But this we cannot say, for there are many distinct kinds of goats, just as there are of sheep, in different parts of the world, and some of these are beardless. But it is enough for us that all he-goats belonging to the race which man has succeeded in taming to his will have beards.

There is, however, another peculiarity about goats which must be mentioned here, and that is that they never have spirally curved horns like those of sheep, no matter in what part of the world they are found.

And just as they differ in this matter of horns, so they differ in their method of using them when fighting. For while sheep rush straight at each other till they come into violent collision, goats rear themselves on their hind legs and throw themselves sideways on their adversary, so as to bring the points of their long semicircular horns to bear with fullest effect.

In a wild state, goats, like sheep, are mountain dwellers, and can take the most astounding leaps from one pinnacle of rock to another with perfect safety.

The goat is a much more intelligent animal than the sheep. So well is this realized that in some countries, as in Somaliland, a few goats are herded with every flock of sheep, in order that they may take the lead in following; for it is well known that sheep will follow a leader blindly, even to destruction. The shepherd walks in front calling the goats, which are followed by the sheep.

In the Alps, in Greece, and in Palestine, the goat is a valuable animal indeed, furnishing milk, butter, and cheese; while the flesh of the kid is highly esteemed, as may be gathered from the frequent references thereto in the Old Testament. In Damascus there is no need for the milkman's cart, for the flocks of goats are driven into the town in the morning, and each goat is milked before the door of the customer. A similar practice is followed in Malta, and in Paris, and elsewhere.

Though no goat produces wool, these animals furnish us with some very valuable forms of clothing. The celebrated Kashmir shawls are made from the soft under-fur of the Kashmir goat, which is mostly obtained from Tibet; while from the Angora goat the valuable fabric known as mohair is obtained. The best of this now comes from South Africa, but originally it was to be obtained only from Turkey, whence the breed was introduced into Africa.

The tame breeds of goats, some of which we have in our own country, are the descendants of the wild goat of the Mediterranean islands, Asia Minor, and Persia. Near relatives of our tame goats are the beautiful ibex and the great markhor goat of the Himalayas. The ibex is still found wild in the Alps of Switzerland and the Tyrol, though it is approaching extinction. It may at once be distinguished by the beauty of its horns, which are ringed and curved like a simitar. The horns of the markhor, which may attain enormous size, are, on the other hand, straight, and spirally twisted like a pair of corkscrews.

WHY DO BATS FLY BY NIGHT?

This is a question that is often asked. But sometimes bats are apparently tempted to venture forth into a sunlight world, where they will dart about with all the zeal and energy which we so commonly notice in the shade of a summer's evening. Such cases are the exceptions that prove the rule, and we at once ask why bats fly by night rather than by day, seeing that they can at will turn day into night, so to speak.

But since these midday ventures are really rather unusual, at least with most kinds of bats, it seems clear that the hours after sunset are the most suited to their great need—the capture of food. And a little observation will show that this is so, since at this time many kinds of insects are on the wing—insects which, from the nature of their flight, are more easily captured than those that disport themselves during the heat of the day. Furthermore, it is possible that night is preferred because there are then fewer enemies to be encountered.

Exactly how the bat discovers his insect prey is not so easy to understand, for the bat is notori-

VAMPIRE BAT FAMILY.

1. VAMPIRE. 2. HEAD OF VAMPIRE. 3. HEAD OF DWARF BAT. 4. HEAD OF HORSESHOE-NOSED BAT.

ously short-sighted, as is shown by the saying, "Blind as a bat." Except the mole, no other of our animals is so degenerate in the matter of its eyes. Two little black, bead-like bodies buried in the fur of the head are all that now remain of what were once large eyes.

It is clear, then, that bats must have some other means of perceiving their prey, and it would seem that this is supplied in a marvelously acute sense of touch. That this sense is far more delicately sensitive than in ourselves, and is therefore more subtle than we can ever hope to realize, is shown by the fact that a bat can pursue its flight about a room which is absolutely dark, and beset with a complicated series of entanglements in the shape of fine threads, without so much as touching a single thread! This wonderful sense appears to reside chiefly in the delicate skin of the ears, and of the wings, and in folds of skin around the nose. These nose-folds are often of large size, and may take, in some kinds of bats which are found in tropical countries, very complicated, rosette-shaped patterns.

The ears are always large in bats, and in some species, such as the long-eared bat, they are of huge dimensions, being actually longer than the whole body! And, what is still more strange, they can be turned back along the sides of the body while the little creature is asleep! At such times there will be seen two little "false ears" sticking up beyond the fur, looking exactly like a pair of small ears. These are not very noticeable when the real ear is in use, and they serve doubtless as touch-organs to awake the sleeping beauty should need arise.

There is yet another point in which the bat surpasses all its relations, both near and remote, and this is that it can fly. Though the bat and the bird are in this respect alike, their wings are formed on totally different plans. For the bat's wing is formed by stretching a delicate sheet of skin between the fingers of an enormous hand, and along the arm, and still inward until it joins the side of the body, and even includes the hind leg. In the bird's wing a long row of separate ribbon-like plates, overlapping one another—which we call the quill-feathers—takes the place of the fold of skin which serves the bat, and these quill-feathers are fastened along the skeleton of the arm and hand, which is specially modified to afford them firm support. Only three fingers, for instance, are to be found in the bird's hand. The first of these answers to our thumb, and is quite small; the second is very long, and forms the main support of the quill-feathers; the third is, like the thumb, small, but at the same time is much longer than the thumb. However, we need not go into the details of the bird's wing just now.

Where do bats sleep? Where do they pass the long hours of the summer day? Many of us must have asked this question when, after a day of broiling heat, we have watched these little creatures flitting about, up and down, now lost in the shadows and now almost touching us. In what cool and sheltered nook have they hidden? The game of hide-and-seek will have to be played with more than ordinary skill, as a rule, before this secret is discovered. Church towers, and holes in the roofs and thatches of houses, hollow trees, and caves, are favored places, but these are not easily explored. But if search here is impossible, then give it up altogether, for the task is hopeless.

There is an enormous cave in Kentucky in which millions of bats are to be found, sheltering while the sun is shining. They cling to the rock and to each other in such thick clusters that forty bats were once counted in a space of a few inches. The Egyptian Pyramids swarm with bats. Inside all is dark as the darkest night, even on the brightest day, and travelers are astonished to find bats dashing about their heads. Dazzled and frightened by the candles, they fly about in great alarm and beat against the face, as a moth beats against the globe of the lighted gas.

In winter a host of creatures disappear, and many fall into a deep sleep, and in this state they remain till wakened by the warmth of spring. The bat is one of these deep sleepers. As soon as the autumn nights grow really chilly, the bats hie them away to some snug and secure retreat, such as a hollow tree, the roof of a cave, or the belfry tower of a church; and there, hanging by the legs, head downward, and with their wings folded round them like a mantle, they soon drop off into a heavy sleep.

These retreats, or hibernating places, are occasionally discovered, hundreds of bats sometimes being found huddled close together. And we regret to say, as often as not they are killed, the stupid person who has broken into this slumber-chamber supposing that bats are in some way noxious animals—why, he does not know, and he is generally too thick-headed to take the trouble to find out. As a matter of fact, they are among our most useful creatures, helping to keep the air free from flies and other annoying insects.

WHY DOES AN OWL COME OUT ONLY AT NIGHT?

Quite a number of animals, and some other birds besides owls, are *nocturnal* in their habits—that

is to say, they are adapted for living their lives generally during the hours of night. If we want to understand why an animal comes out at night, or why it comes out in the daytime, we must, as a rule, ask ourselves: What is it that makes an animal active at one time of the day rather than at another? The answer to this question is generally to be found in the search for food. So it is in the case of the owls. Owls feed chiefly upon mice and other small creatures that are active during the hours of the night, and so the owl, with its peculiar noiseless flight, due to the fact that its plumage is so soft, comes out at night in search of food. It is because of this habit that the pupils of the owl's eyes are adapted for seeing at night, being made to open very widely to catch every ray of light that there may be, and so see where other animals would be unable to see.

WHY DO THE BIRDS FLY SO HIGH?

If you stand on the top of a high building in New York on a sunny day, you can see nearly all over the city. The higher you go the more you can see, if your eyes are strong enough. Many birds have very strong sight. Their eyes can see as well as ours would if we used a telescope.

The big birds look down from the great height at which they are flying, and they see many birds flying below. These birds below watch the earth. They see food thrown away by men and placed in the garden by children, and in a moment they fly down to get it. The bird which is right up in the air knows what they are doing, and swoops down quickly to take its share. These birds get a good meal. If they did not eat that food it would soon become bad in the sunshine, and make us ill; but it serves the birds for a good dinner, and by eating it the birds save us from being ill. So we see how in all parts of the world Nature looks after her big family.

HOW IS IT THAT A BIRD CAN FLY WHEN IT IS HEAVIER THAN AIR?

People who spend their lives in destroying the lives of other creatures know that, when a bird is shot, it falls; in other words, a dead bird obeys the force of gravitation exactly as a hail-stone, or a rain-drop, or a meteor must do. The force of gravitation is always acting even on the living bird. It is therefore plain that some force is produced that acts against the force of gravitation, balances it when the bird maintains its level in the air, or more than balances it when the bird rises in the air. This force is produced by the life of the bird. It can be produced in other things that are not alive, as in a flying-machine, whether a real one, or one of the toy butterflies that we play with. In any case, there is produced a force that acts in the opposite direction to the force of gravitation, and is, for the time being, superior to it. We know that, in the case of the bird, the force is produced by burning the sugar in its muscles; in the case of the aëroplane, it is produced by burning the petrol in the engine: in the case of the toy butterfly, it was produced by burning the sugar in our muscles when we wound it up. Foolish people sometimes speak as if these were cases of defying one of Nature's laws. They are nothing of the sort. Gravitation goes on acting on the bird, whether the bird rises or falls. But, when the bird rises, a greater force is being opposed to the force of gravitation.

Though the bird's body is heavier than the air, yet it is very light, and is most beautifully made, so as to be as light as possible. There are great spaces in its body which are filled with air, and they say that the air can even get into its bones.

Still, though this helps the bird, of course, yet all the same its body is heavier than the air, and it will fall unless it uses its wings. The bird knows this, and sometimes it wants to fall quickly. It folds its wings and simply drops as you or I would if we fell out of a balloon. The strongest muscles in the bird's body are those which press the wing downward, and if it uses them quickly enough, this keeps its body up or even raises it. When we swim we do what is really just the same thing, though it is not nearly such hard work to swim, really, as it is to fly. No machine that man has ever made is as clever as a bird for flying, because there is no machine in the world that can do so much work as a muscle in proportion to its weight. If only man did not have to take with him up into the air the engine that gives him his power, then he could make flying-machines easily enough.

HOW DO THE BIRDS FIND THEIR WAY?

We know that many birds fly away over land and sea to warmer countries when our summer ends, and return when it begins again. This flight of many miles is called migration, and is indeed one of the wonders of the world. We say that instinct guides them; but this does not tell us how instinct is able to do so marvelous a thing. When we cross the seas we are guided by those who have been that way before. We have charts and pilots and compasses, and even then we sometimes make terrible mistakes.

But the birds have none of these things. They

do not even take provisions with them; and we know that some of them become exhausted with their long flight, unsupported by food, and so perish; while not a few, when they reach their destination, are nearly dead. Yet the wonder of their flight, and their guidance, remains.

If we pretend to answer this question, we should have to pretend to be wiser than any one who has ever lived. We can only guess that perhaps the older birds teach the younger ones, as happens with ourselves; and if any one finds it hard to believe how they can remember, all we can say is that birds have wonderful memories for these things.

We know that some people can never find their way. They turn to the left when they should turn to the right, and so on. Other people scarcely ever make a mistake, even though they have only been once in a place before.

Probably birds and many other animals are even cleverer than the cleverest human beings in this respect. Perhaps, if you bandaged a bird and "turned him round three times"—as when you play games—he would remember just how far and often he had gone round. But when they turn *you* round, you don't know whether you are facing the fireplace or the window. Your brain can't remember the turnings as the bird's brain does.

HOW DOES A PIGEON FIND ITS WAY HOME?

This is a deeply interesting question which has long been a puzzle, and men have made all sorts of guesses to understand how pigeons can find their way home even over long distances, when they have been carried away in a closed box through which they could not see.

Most people think now that the bird finds its way simply by seeing. It has wonderful eyes. As it flies high in the air it can see for very great distances. As a rule it flies about until it sees something it knows, and then it makes for that. Sometimes the pigeons fail; and young pigeons are not so clever as old ones, probably because they do not remember so well—for you understand, of course, that the pigeon must remember in order to find its way home, and so we know that the pigeon has memory, as we have.

It used to be thought that the pigeon had a special sense, which was called a sense of direction; indeed, some think now that this is true of birds in general. But most people now believe that the pigeon's sight and place-memory are sufficient for it. We have to realize the enormous distances that it can see when it flies high enough, and also that it does not require to see its home, but merely any place that it remembers. An old pigeon has often flown a good deal round its home, in all directions, and if it can recognize any point on these occasions, that is enough for it.

HOW DO BIRDS KNOW HOW TO BUILD THEIR NESTS?

If you had asked me instead how do spiders know how to make their webs, the answer would have been just the same as the answer to this question; and, though we can tell you something about it, yet no one has really explained how it is that animals are able to do these wonderful things. It is by the power of what we call instinct. We human beings have very little instinct; we have to learn for ourselves almost everything that we do. We cannot write or read instinctively, and if we are to learn well we must practise, and we must have help from older people to teach us. Only we have this advantage, that there is *no limit* to what we can learn.

The instinct of animals, however, shown in the spider's web or the bird's nest, or a thousand other things, is quite different. There is no learning at all. Many animals have to do a most difficult thing only once in their whole lives, and after doing it they die; and we know for certain that they have never seen any other animal do it. They have never learned, they have never practised, and yet they do it perfectly. That is the power of instinct; but the weakness of it is that it can only do what it is made to do, and it is for this reason that intelligence is so vastly superior to the best instinct. You will say that I have told you a lot about instinct, but nothing about where it comes from; and that is quite true, because no one knows.

WHY DO BIRDS CAST THEIR FEATHERS?

Feathers become worn and torn and broken, and must be replaced. We do not know how birds manage to moult their feathers; it is one of the wonderful provisions of Nature, whose effects we see without being able to say exactly how they are caused. But the moulting of birds is similar to what takes place in other forms of animal life. Horses grow long coats of hair in winter which they shed in summer. Dogs cast their coats. Snakes cast their skins; crabs and other shell-fish cast their shells. If a crab lived always in one shell his body could never grow any bigger. At a certain time in the year his flesh becomes very watery, so that he can draw those

great claws of his through the narrow opening at the top of the shells in which they are inclosed, and he comes out of his shell almost as soft and pulpy as an egg in its skin with its shell removed. Birds are never left bare like this. They moult gradually. Some are so completely robbed of their strong feathers that they are glad to go into hiding until the new ones grow. They are then as defenseless as is the stag which has shed its mighty antlers.

WHAT WAKES UP THE BIRDS?

Sleep is a very mysterious thing that we do not know much about yet, but at any rate we are certainly mistaken when we think that sleeping creatures only wake up when something arouses them from outside. It is possible to study the exact amounts of noise that will wake people at different parts of the night, and we know that as morning approaches, healthy people or animals sleep less and less deeply, so that things wake them which would not have wakened them in the earlier part of the night. Healthy creatures probably either wake up quite apart from anything outside them, and because their brains have now rested long enough and are ready to start work again; or else their brains are just ready to wake up with the least thing, and some little noise or light—it does not need much then—gives the necessary signal.

So we may say, and it is perfectly true, that it is the light which wakes the birds, just as it is the dark that sends them to sleep. We know that during a total eclipse of the sun, when it gets dark in the daytime, the birds fold their wings and start to go to sleep. Of course, they very soon find out that they were wrong. But though the light of dawn, or perhaps the voices of other birds that have awakened a little sooner, seem to do the waking of the bird, yet we must understand that waking and sleeping, in all living creatures that wake and sleep, really depend, not on what is happening outside, but on changes that go on steadily to and fro inside the creature in question, especially in its blood and brain.

WHY ARE BIRDS' EGGS OF DIFFERENT COLORS?

We know, of course, that the differences in color depend upon the presence in the various shells of various coloring substances or pigments, and it is ever interesting to see how a particular kind of bird always produces the same kind of color in its eggs, just as it produces a particular kind of color in its own feathers. We do not think that the particular kind of food the birds feed on, nor yet the particular surroundings it lives in, have much to do with the special color of its eggs. This must really depend upon the particular chemistry of the body of the bird. We do not mean that you cannot change the color of hens' eggs, for instance, by food, but you will never get a hen to lay a speckled-green egg. The color of the shell is really as special to the particular bird as any of the things by which we know one bird from another.

WHAT USE ARE THE DIFFERENT COLORS OF BIRDS' EGGS?

If we compare the colorings and markings of a great number of birds' eggs with the places in which they are found, we discover that in a large number of cases the eggs are so like their surroundings that they are difficult to see at all unless we look quite closely. For instance, a ringed plover's egg has the same general coloring as the sand on which it lies, and it is spotted over with black dots which look like tiny shadows. This makes it difficult to see the egg at all. In other cases the blotches or markings on the eggs look like an irregular piece of dark material lying, perhaps, on the beach. Thus, the eggs of the tern sometimes look like stones or spotted pebbles, and, on the other hand, the stones themselves look so like eggs as to be easily mistaken for them at a slight distance; so that the reason for the coloring of eggs is no doubt to help them to be hidden from sight.

WHAT DO THE BIRDS SING ABOUT?

Sometimes *we* sing just to show that we are cleverer than other people, and when we do that we do not feel what we are singing, and every one is glad when we stop. But the birds only sing when they must—when their feelings find their way out somehow. Then they try to tell the world how happy they are. The feelings that birds sing about are always happy feelings. When a bird is ill, or miserable, or unhappy, it never sings. Generally birds sing to express their feelings of love, and to call to their mates and their friends when they want company. At other times they sing simply for the joy of living, as the lark sings when he goes up into the sky. He sings for the joy of his nest on the ground, and for the joy of the light, and the joy of the air, and the joy of freedom. We believe that the singing of the birds was the first music that was heard on the earth. But do remember the most beautiful thing about the birds' singing,

which is, that they never sing so that people may say, "What a beautiful voice you have!" but always because they have some beautiful feeling which makes them sing.

DO BIRDS ALWAYS SING THE SAME SONG?

We do not yet know as much as we should about the songs of birds, and this is a pity, because what we do know is very interesting. In the first place, we are sure that various kinds of birds have various songs of their own, more or less as the various kinds of animals make sounds of their own.

But the more we study other kinds of living creatures, the more we find that individuals differ much as we do. We think that all Chinamen and negroes look the same; they think that we all look the same. We think that the sheep of a flock all look the same; the shepherd knows that they differ just as we do. And birds of the same kind vary to a certain extent.

It has been noticed that certain kinds of birds change their song as the year advances. The tune is not quite the same in early spring as it is in summer. Sometimes the difference is definite, and can be expressed in terms of music.

Various interesting results are observed when a bird of one kind tries to teach its song to birds of another kind, as sometimes happens. But we do not yet know much about this. It is very remarkable, however, that young cuckoos, though they are hatched in the nests of birds of other kinds, keep their own particular kind of song.

WHY CAN PARROTS TALK, AND NOT OTHER BIRDS?

It is not quite true that other birds cannot be taught to talk, but it is quite true that some birds will learn and others will not, and you are quite right to ask what makes the difference. We think the way in which the bird hears goes for a good deal. If you do not hear properly, then you cannot imitate the sounds that other people make. That is why many poor deaf children are dumb. It may be that parrots have better ears than many other birds. We think it is also because these birds have brains which help them to distinguish sounds better. You see, talking is really a matter of the brain, far more than of the teeth and tongue and lips. But we do want you to understand what the talking of the parrot really is. It is utterly different from the first talking of a child as it learns, though very likely the child does not talk as distinctly as the parrot does.

But, when the child talks it means something, even though, very likely, you cannot make out what it means. We believe that the parrot never means anything because it never understands what the words it hears mean. We are sure that the parrot is just like the wonderful machine called a phonograph. You talk into it and it talks back at you, but it understands nothing. Therefore, the talking of the parrot, though it is clever in a way, is really less clever than the way in which insects tell each other what they want.

If we could believe that a parrot understood what it said, we should have to put the parrot on something like our own level in the scale of being. But we find that all words are just the same to a parrot, and it will repeat a word like algebra, shall we say, or hypnotism—if it hears it often enough—just as readily as it will repeat "pretty Polly." It is just a living echo, and no more, and the process that goes on in the parrot's brain is no more and no less than what goes on in our brain when we simply imitate or repeat the sounds of words spoken to us in some foreign language of which we know nothing.

WHY MUST THE CLAWS OF CAGED BIRDS BE CUT?

Such things as bristles, hair, teeth, claws, and nails behave differently in various animals, according to the kind of use they are likely to be put to. The rule, on the whole, is that when any of these things are liable to be used constantly in such a fashion as to rub them away, they keep on growing continuously throughout the life of the animal.

Our own teeth do not grow continuously, but the teeth of animals often do so. For instance, a hare may die of starvation because it has lost one of its teeth and the tooth in the other jaw, opposite it, having nothing to rub against, grows and grows, and at last forces the poor creature's mouth open and so kills it by starvation.

Claws and teeth follow the same rules in many ways, for they belong to the same class. A bird's claws are meant to be constantly used. When we keep birds captive, and feed them without work on their part, the claws go on growing because they are no longer worn away by use, and the friction, or rubbing down, which that involves, so they require to be cut by us.

CAN ANIMALS THINK?

The answer to this question depends entirely on what we mean by the word "think." We should not say *think* when we mean *feel,* and we should

not use the word thoughts to mean feelings, as nearly every one does. To think is really to put one thing and another together in our minds, so as to make a link between them, and when the two things are linked together like this, that is a thought. To feel that you want your dinner is not to think, but to say to yourself, "I am hungry," is a thought, because you have put together in your mind your idea of yourself, and the idea you have of that feeling which we call hunger. So, if we use the word properly the answer must be that animals can scarcely think at all, but that some of the higher animals—such, for instance, as dogs—do, beyond a doubt, act sometimes in a way which can only possibly mean that they have somehow "put two and two together" in their minds, and to do that is to think. The proper name for this is the *association of ideas.* When we begin to connect things in our minds we begin to think, and then we say that one thing makes us think of another. The best thinkers are those in whom this association of ideas is widest and richest and most varied, and who depend on deep connections, and not shallow, trifling ones, in the things thought about.

If, then, with this in our minds, we study the behavior of dogs or elephants or birds, or many other kinds of animals, we find abundant proof that they do associate ideas, "put two and two together," and often act accordingly on the conclusions thus reached, just as we do. But the thinking of the cleverest animal is always about simple things, and deals only with the simplest questions. A child of two years old is a far better and deeper thinker than the cleverest animal that was ever born.

CAN ANIMALS TALK TO EACH OTHER?

People used to think that only human beings could talk to each other, and there is no doubt at all that no other creatures can talk one thousandth part as well as we do. But no one who knows animals now doubts for a moment that many kinds of animals can talk to each other. Only it is not our kind of talking. Monkeys, for instance, make many kinds of sounds with their mouths which have different meanings; only they do not express ideas or make assertions that the earth is round, but they express their feelings. A baby expresses various feelings with its mouth long before it can talk, and so many animals can express fear, joy, anger, and many other feelings with their voices, and their fellows can understand them. That is talking of a kind.

But though monkeys probably come nearer to us in talking—though still very, very far away—than any other animals, yet many insects, which are very simple and humble creatures compared with monkeys, can talk wonderfully in their own way. We mean especially the social insects, like ants and bees and wasps. If they could not tell each other what they felt and wanted, they could not live together in societies as they do—societies, remember, from which human beings have a lot to learn yet, societies in which very few children die. The insects have long feelers, with which, as it seems, they can touch each other, and say what they want to do or how they feel. But we could write a book on this, and we must stop.

DO ANIMALS FEEL PAIN AS WE DO?

This is not a question that can be answered directly; indeed, when we come to think of it, we shall see that no one of us can really compare the amount of pain he feels with what any one else feels. We cannot feel any one else's pain, and so we can only judge questions like this indirectly.

Yet it is certain that animals feel pain far less than we do. Different kinds of human beings feel pain differently. Small babies and children are probably much less hurt than grown-up people are by the same thing, though we may be misled by the fact that grown-up people usually control better the results of pain.

Probably women are slightly less sensitive to pain than men. It is well known that, on the average, they can drink fluids hotter, or hold hotter plates, without pain, than men can. The lower races of mankind differ immensely from ourselves in this respect. For instance, a negro will often cut and mutilate his body, and take very little or no notice of it.

So we find that animals feel pain far less than we do. The stroke of a whip which would hurt us terribly for hours and leave a mark for days, must certainly feel very different to a horse; and we know that a horse will contentedly eat his food and never move his head in the slightest while a vein or an artery is being opened in his body.

DO ANIMALS DREAM AS WE DO?

As we cannot ask animals the answer to this question, we must find it out as best we can by arguing from other facts we know. The case is the same regarding babies and very small children before they can speak. But in all these instances we have quite good reason to believe that dreams occur, just as they occur among ourselves. As soon as children can tell us about themselves we find that they have dreams, and

so we naturally expect that they must have dreams of some kind even sooner.

Then, as regards children, and animals too, we know that their brains or senses are made on the same principles as ours in every respect. They are exposed to the same influences as ourselves, and so it would be very curious indeed if the same results, such as dreams, did not follow from what are practically the same causes.

In dreams we have feelings of various kinds, and just as our faces largely express our feelings when we are awake, so they do when we are asleep. If we observe the ways in which such an animal as a dog, for instance, expresses its feelings when awake, we may look out to see whether it ever shows the same sort of expression when it is asleep—perhaps only for a very brief moment, but clearly, nevertheless.

We do find signs in animals which plainly show that they are having feelings of one kind or another—and that means that they are dreaming. Of course, their dreams will differ from ours, just as ours differ. A musician and a painter have very different dreams, and we should expect a dog, in which the smell part of the brain is very important, to dream smells, just as we dream sights and sounds.

HOW CAN SOME ANIMALS DO WITHOUT FOOD SO LONG?

A VERY good example of this is to be seen in our common snakes, which, after feeding heartily during the summer months, retire into their winter quarters, where they take no food at all. The reason that they are able to do this is because during the months of activity, when they were feeding, they were enabled to store up in the body a large quantity of fat, which represents the excess of the food taken, over what was required at the time. Now, this fat can be used by the body itself while the animal is not actually eating. It is gradually absorbed, or used up. So we find that a snake which, at the end of the summer, was round and fat is extremely thin when it comes out of its winter quarters in the early spring. Many animals have this property of storing up food in the shape of fat in a greater or less degree; indeed, if it were not for this they could not live through the periods when there is very little food to be got.

WHY DOES A DOG GO ROUND AND ROUND BEFORE IT LIES DOWN?

THE answer to this question lies in the answer to another: What is a dog? We are so familiar with animals like dogs and cats, and horses and pigeons, that we often forget their history. Really, the dog is not a natural animal. All natural animals are wild; but these are tame—domesticated, as we say, which simply means made homely.

Now, these domestic animals very often follow the habits of their wild forefathers, though hundreds of generations may have passed since those forefathers were wild. This is a very wonderful fact, showing how things are handed on from parents to children, very largely without reference to what the outside circumstances may be.

The dog, turning round and round before it lies down, gives us an instance of one of these inherited habits.

As the habit is really inherited, and is natural in the dog, and has not been taught it, by itself or any one else, we call it an instinct. If it were a thing learned by the dog, like a trick, it would not be an instinct. The dog's far-away ancestors were animals that lived in the jungle-grass, and if they wanted a comfortable bed they had to turn round and round a few times so as to level the grass.

This leads to a further question, too difficult for us to answer until we have learned more than we yet know. We might ask: How did this habit first begin? For it must have had a beginning; but how it began we cannot yet say, though we are fully aware of what happens when it has begun.

HOW DOES A DOG KNOW A STRANGER?

A DOG has wonderfully good eyes, but it has a still more wonderful sense of smell. Our own sense of smell is so very feeble and unimportant that only after we have made a long study of animals can we realize how useful and delicate this sense may be. Thus a dog "knows a stranger" chiefly because the stranger has a strange scent. If the stranger wore the clothes of the dog's master, then the dog would take him for his master, even though the stranger looked very different. After a time, very likely the dog might begin to feel uncomfortable, and act as if he thought something was wrong somewhere.

But, you see, every creature forms its judgments mainly by means of the particular sense which is best developed in it, and which it has therefore learned to trust best. We know people by our eyes, and though sometimes a man's voice may be exactly like the voice of a friend, yet we do not usually think that it is our friend if our eyes do not tell us so. Just in the same way the

dog trusts his nose rather than his eyes, because his sense of smell is his best sense. Lastly, do not forget that it is because the dog has the wonderful thing called memory that he "knows a stranger." It is as if he said to himself, "This is not a smell I remember"—that is to say, it is a strange smell.

WHY HAVE HORSES HAIR AND SHEEP WOOL, WHEN BOTH EAT GRASS?

It is one of the most wonderful facts about living creatures that they can turn into the substance of their own bodies almost any kind of food. As long as what they eat contains certain classes of chemical substances, they can use it as sources of the life of their bodies, and the life of their bodies produces the particular things that suit them.

Hair and wool are not really very different; wool is, indeed, only a kind of hair, and some races of men have quite woolly hair. But you might take certain kinds of food material, such as white of egg, and give it to any kind of animal, and it would be turned by each animal into a different thing—a bird would turn it into feathers, a sheep into wool, a fish into scales, a lobster into its shell, and a porcupine into quills. All this shows us how completely the life that is in every creature transforms its food, and can make, out of almost any food materials, the particular kind of thing that it is fitted to make. But no kind of food that you can choose or imagine will make the horse grow scales or the fish grow hair or the lobster grow feathers. The particular kind of life in each creature can do what it is suited to do, but can do nothing else.

HOW LONG DO ANIMALS LIVE?

We cannot give exact figures about the age of animals as we can about the age of men and women. We know the age to which men and women live, because the date of their birth is entered in an official register, and the date of their death also is recorded. Famous animals which are kept by men are registered in books kept for the purpose, so we know the age of prize horses, cattle, and other animals. But this does not help us quite as it might, for many animals, when old, are destroyed. If wild, they might live considerably longer.

The prize for the land animals has to be given to the tortoise. This animal lives, under favorable conditions, for between 300 and 400 years. Next, we have to take another reptile. It is the crocodile, which, given fair play in its native wilds, can live for 300 years.

If we believed all the stories we read, we should have to say that the toad, an amphibian, lives far longer than this. It is said to live shut up in a rock, or a tree, or in a piece of coal, and to grow fat on nothing, a close prisoner for thousands of years. But we know that we must not believe anything of the sort until we have much better proof brought forward.

It takes an elephant a long time to grow up, and it takes him a long time to wear out. Well treated, he should live to be a hundred. That is the age to which the eagle is supposed to live, but some people put down the age he may reach as 200 years. Even that is young compared with the life of the whale. This can be shown to last for 500 years. We have not a birth certificate with the whale, and he does not invite us to his birthday parties and tell us how old he really is. Clever men, however, say that an ordinary whale lives to the age of 500 years, while some whales have been caught whose appearance has made the scientists believe them to be 1000 years.

In the following tables the extreme ages of animals like the whale and eagle and tortoise are not given. The tables merely set out the ages to which certain animals often live, not the age to which the very fortunate animals among them may possibly reach.

THE NUMBER OF YEARS THAT ANIMALS LIVE

Rabbit	5	Horse	27
Sheep	12	Camel	40
Cat	13	Lion	40
Dog	15	Elephant	100
Goat	15	Crocodile	300
Cow	25	Tortoise	350
Pig	25	Whale	500

THE NUMBER OF YEARS THAT BIRDS LIVE

Wren	3	Canary	24
Thrush	10	Crane	24
Robin	12	Peacock	24
Blackbird	12	Skylark	30
Hen	14	Sparrow	40
Goldfinch	15	Goose	50
Partridge	15	Pelican	50
Pheasant	15	Parrot	60
Lark	18	Heron	60
Nightingale	18	Crow	100
Pigeon	20	Swan	100
Linnet	23	Eagle	100

It will be noticed that many animals live longer than we do, as it is very rare for man to reach the age of a hundred years.

WHAT MAKES THE LOWER CREATURES DIE?

Next to starvation, or lack of food, as a cause of death among lower creatures, is murder, if we

may call it by so ugly a name. This does not apply very much to the vegetable world, as plants do not live upon each other to any great extent; but enormous numbers of young plants die because they are eaten by animals, and a small number of animals die because their bodies are invaded by tiny plants that live upon them. In the animal world, killing and being killed for the sake of food goes on without ceasing.

We must not think of it as if it were a very cruel process, involving a terrible amount of pain, for that is not so. Animals, as we have before said, cannot suffer pain to anything like the same extent as we do, and their death is usually very swift and merciful. A single human being, in the course of his life and death, usually suffers far more pain and distress than many animals put together. What we call disease, a far more painful and cruel thing than being instantly killed, accounts for comparatively few deaths among the lower creatures.

WHICH IS THE MOTHER—THE HEN THAT LAYS OR THE HEN THAT HATCHES?

You might almost as well ask which is the mother, the woman who gave birth to the baby, or the fire that keeps it warm, or the cow that gives it milk when its mother cannot? And yet the question is well worth asking and answering, for there are two parts to being a complete mother. One is bodily, or physical, and is, of course, the *real* motherhood. It is the real motherhood, for the chick that develops from the egg really gets its life from the hen that laid the egg, as does the baby from its real mother. Both egg and baby require more "mothering" of a kind, and that is why we may say that *complete* motherhood has two parts; but we see which part is more important, when we remember that it is quite easy to hatch a hen's egg by putting it in a box that is kept warm. This is called an incubator, and so the question might almost run: Which is the mother, the hen that lays the egg, or the warm box that hatches it?

Among human beings the second part of motherhood, though not the real and bodily part, is more important than among any other creatures; for babies are more helpless, and are longer helpless, than any other young creatures, and so need more care. So we must say that though the real mother is she who gave birth to the baby, yet we can call her a complete mother only if she cares for the baby after it is born; just as the hen who lays the egg and then takes care of it, and of the chick afterward, is a more complete mother than the hen which only lays the egg and then does nothing more for the young and needy life that is within it.

DOES A HEN KNOW THAT CHICKENS WILL COME OUT OF HER EGGS?

One of the greatest of facts in the animal world is what is called instinct, and the mighty difference between our minds and those of the lower animals is that in us instinct has become largely changed into a much more wonderful thing which we call intelligence. One of the most important facts about an instinct is that the animal goes through the action without knowing what its purpose is and what will come of it. If an animal could foresee the consequences of its acts, then it would be a reasoning and intelligent being, worthy to rank beside ourselves.

This is true of all instincts, that the action is done because something within the creature impels it to perform that action, but with no knowledge of its use and purpose. Thus, when a baby instinctively sucks a bottle it does not know that the object of doing so is to supply itself with material and power for its life.

It may possibly be that in some cases an animal of the highest type, such as a dog, may notice, after a number of times, that certain consequences follow upon its instinctive actions, and so it may get to know what will happen, just as we do after a time when we exercise our instincts.

But it is very unlikely that the hen, whether it be the first time or the twentieth time that she sits, has any idea except simply that things like eggs are very good to sit on. This is true, even though she is glad to see the fluffy little chickens when they come.

WHAT MAKES THE POISON IN A SNAKE'S FANG?

A snake's fang is an eye-tooth, or canine tooth, as it is called, corresponding to the sharp pointed teeth that we have at the corners of the jaw between the front teeth and the back teeth. In the case of the poisonous snakes, the tooth has a special channel in it through which the poison can run when the snake bites. The snake, like ourselves, has certain glands, but in our case these simply produce the saliva, which helps us to chew and digest our food.

In the snake, however, these glands do much more than that, and especially the gland which corresponds to the one we have in front of the ear, the one which gets so big and painful when

we have mumps. In the snake the business of this gland is to produce the poison. It runs along a little tube from the glands on each side of the mouth to the poison teeth. When the snake bites, the muscles of the jaw, which make the teeth meet, also squeeze upon the glands in these tubes in such a way that a little of the poison is forced through the channel in the fang, and left in the victim's body. The amount of poison thus injected is, as a rule, exceedingly tiny, but the venom, or poison, of many of the venomous snakes is among the most deadly of all poisons, and a mere portion of a drop will kill.

This is a deeply interesting question from the widest point of view, because it is so remarkable to discover that in certain kinds of animals parts of the body which are possessed by so many other kinds of animals, and which were certainly evolved for one purpose in the first place, are turned to a quite new and special purpose in these particular cases. In non-poisonous snakes, these glands, which are so poisonous in the venomous snake, look just the same, yet produce nothing to hurt any one.

WHERE ARE A FROG'S EARS?

One might well ask where the ears are, when we cannot see them. But we must remember that an ear is simply something by means of which the animal can hear, and not necessarily anything that we can see. As a matter of fact, what we call ears are merely outside flaps of skin which, when they are large, serve the purpose of collecting the sounds in the air around. The real hearing is all done inside the skull, and in the case of the frogs, as in the case of birds and lizards, there is a little hole some distance behind each eye, and not far from the angle of the mouth. The frog is entirely without any outside ear at all. Inside this hole is the internal ear, and in the frog there is a middle ear, too, for the purpose of conducting the sound to a special nerve, which takes it to the brain, where the real hearing is done.

WHY DO WORMS OR FROGS SWARM ON ROADS AFTER A STORM?

Frogs are what are called amphibious animals—that is to say, they live part of their lives on the water, and part of their lives on the land—but they are never very active unless there is a good deal of moisture to be had. In fact, when the ground gets dried up, and it gets very hot, the frogs disappear down crevices into the dampest and coolest corners they can find, and as long as the nice dry weather lasts one does not come across many frogs in their country walks; but if there is a spell of wet weather, such as the frog delights in, he may be seen jumping about over the wet grass, and the wetter it is the better he likes it. His activity, like that of many other animals, is directed chiefly to the search for food, and it so happens that the particular kind of food the frog likes is also more abundant in wet weather. As a matter of fact, although the young frog or tadpole lives on vegetables, the adult frog lives on insects and worms and such small animals, which, however, must be moving about if they are to excite his interest. As this happens generally after a storm, so we see the frogs especially at that time.

WHAT HAPPENS TO SNAILS WHEN THEY DIE?

We may sometimes find, while walking along the seashore when the tide is low, the white bones of a bird or some other animal. And, if so, we may ask why do we not find the dead bird, but only its bones? Perhaps we may say at once that it was because the bones of the bird were harder than the rest of it, and lasted after all the soft flesh and muscle and everything else had decayed and disappeared. So it is in the case of the snail. True, unlike a bird, the snail has not a skeleton, because the body of a snail is a very soft substance, like that of a slug. When the snail dies its soft body is easily broken up into many different chemical substances, and all the moisture in it evaporates, and all that is left is the hard shell, which will last a long time. So that the answer to the question is simply that the harder a thing is the longer it will last, no matter whether it happens to be the shell of a snail or the bones of another animal.

WHAT MAKES THE CATERPILLAR TURN INTO A BUTTERFLY?

Whenever we ask about any fact of a living thing, we have to make our choice and balance more or less between the effects of its own nature and the effects that its surroundings work upon it. In the case of this question, every one will agree that the important thing is the nature of the caterpillar.

By altering its surroundings as regards temperature, light, moisture, and so on, we can hasten, or retard, or slightly affect in other ways, the change that occurs to the caterpillar. But such experiments as this only make it more clear that the real cause of what happens is to be found in

the nature of the caterpillar itself. If we look at a caterpillar and do not think of what it will become, we shall agree that it is in most respects a sort of worm. On the other hand, if we look at the butterfly and forget what it was, we shall agree that it is a sort of insect.

There is a vast difference between a crawling worm and a flying insect. Now, if we look at a tadpole, we shall agree that it is a kind of fish, breathing the air dissolved in water, like other fishes; but a frog is no fish, and breathes air as we do. The explanation, we believe, is that the frog, and all creatures like frogs, are descended from fishes, and so in its earliest stages each of them is a fish. So also we are bound to believe that the insects are descended from the worms, and that is why the caterpillar turns into a butterfly. In a large book it might perhaps be possible to begin to do justice to this question.

HOW DOES A SPIDER SPIN ITS WEB?

Great men say that nothing is more wonderful than the cleverness of the spider. The silk of which it makes its web comes from its body through tiny tubes, like the finest hairs. Many of them come out at the same time, but after leaving the spider's body they are all formed into one rope of silk, which is so thin that a hundred of them together are only as thick as a hair. The end of the silk is fastened to a twig or a leaf or a piece of wood. Sometimes the spider makes the fastening itself, or it may let the silk float from its body for the wind to blow it about until it touches something and clings there.

When both ends have been made fast, the spider is able to run down it and fix several more threads, perhaps twenty, all fastened to different points, but meeting in the middle. These are the cross-ropes of the web. Then other lines have to be woven round and round these, making perhaps twenty rings. All this beautiful silk has come from the spider's body. The spider works hard and fast, and when the web is begun the work is finished in less than an hour. The web is then so strong that the wind cannot blow it away and the rain cannot break it.

The purpose of the spider's web is to catch insects, so the spider has still much work to do. Insects would not be caught in a web if they could walk or fly out of it, and to prevent their escape the spider covers all the web with stuff like glue, which sticks to anything entering the web and holds it fast. We cannot see this glue with our eyes, but there are thousands and thousands of tiny beads of it dotted all over the spider's web.

HOW DO ANIMALS HIBERNATE?

Not only does the hibernating sleep of animals differ greatly from the ordinary sleep of repose, but there are many variations of the degree of torpor into which they sink. Some seem to slumber normally, while in the case of others there is a suspended animation which it is almost impossible to distinguish from death.

In the popular mind winter is the only season in which animals hibernate, but this is an error. In dry countries many kinds of animals are able to survive the long season of drought only by hibernation, or, more properly speaking, by estivation, the latter being the term applied to this condition when it occurs in summer.

Even in cold countries many animals begin their winter sleep before winter comes, which shows that the condition is not induced by cold, nor by lack of food, for the great bat begins to sleep sometimes as early as the end of July, when its insect food is still very plentiful.

Submerged in water of a temperature slightly higher than his own, the hedgehog not only continues to live, but appears to suffer neither inconvenience nor harm. Inclosed in an air-tight receptacle, his atmosphere undergoes a change so slight that it cannot be imputed to breathing. As respiration diminishes, the irritability of the muscles of the heart increases, and thus, without the stimulus of oxygen, although much more slowly, the heart continues to beat. In the absence of the fresh air drawn into the lungs in times of activity, uncleansed and unrevigorated and venous blood passes on to fill the whole system of circulation. In hibernation the waste is very small. The fat accumulated during the plenty of summer and autumn supplies all expenditure until the coming of spring, when, earlier or later, the hibernating animal, having no capital in reserve, begins to suffer the pangs of hunger. In response to the demand, respiration very slowly increases. His oxidized blood flows more quickly, and his energy returns.

Then the bat flies forth once more from the hollow tree in the wood to find the warm dusk teeming with insect life, and the hedgehog comes, it may be from the cavity under the gnarled roots below, to find beetles, worms, and slugs once more among the spring grass.

The hiding-place must be secret and free from intrusion, for the hibernating animal cannot bear to be suddenly aroused. Even the little dormouse, which comes out at intervals to feed, does not survive too hasty an awakening. The heat of the hand gradually passing through the nest or the warmer temperature of a room is enough. Then

he awakes refreshed, full of activity, and with a disposition speedily to become tame and make friends. But if you warm him suddenly back to life before he has gradually breathed the torpor out of his blood and established an equilibrium between his respiration and muscular irritability, his heart will beat at a tremendous rate, and in a few minutes he will be dead.

Some animals hibernate in solitude, while others are very sociable in their winter arrangements, notably the skunks and racoons. Bears are morose and solitary beasts, and keep to themselves.

The woodchuck sleeps soundly enough to make even the Seven Sleepers appear like victims of insomnia, and he thus makes up for all the other creatures who are light sleepers. Tame woodchucks that have been stored in barrels in barn or cellar to pass the winter have been taken up and carried miles in the arms of their youthful masters without their nap being in the least disturbed.

In early winter a fat woodchuck may be placed near a fire for half an hour without its making the slightest apparent change in his condition. He is a disagreeable little beast, however, if rubbed and warmed until thoroughly awake during the hibernating season.

The temperature of the body in hibernation is reduced very nearly to that of the air, but it returns quickly to the normal when the sleep is over. The loss in weight is from thirty to forty per cent.

Reptiles, amphibians, and some fishes hibernate, as well as some insects. The land reptiles bury themselves below the frost-line and wait for spring, or crawl into the crevices between rocks, snakes sometimes passing the winter wrapped in a tangled mass composed of a number of their species. Frogs bury themselves in the mud at the bottom of ponds, and if dug up and placed in water will swim away, though their movements are sluggish.

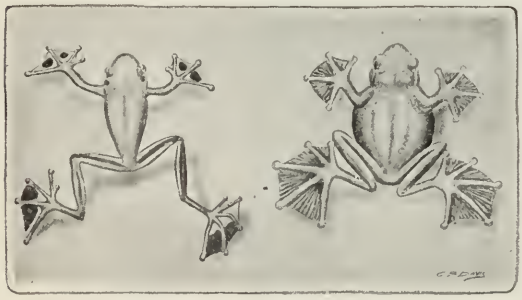
There are several varieties of butterflies that hibernate, and one of the strangest of Nature's problems is how it is possible for a creature so fragile and delicate as the gnat to endure, for many weeks and even months, the cold and frost of winter. It will come out to dance in the sunshine when there is a bright day, and return to its hiding-place when hard times come again.

"VIEWING THE PROCESSION." BY FANNY MOODY.

FLYING THINGS

SOME STRANGE AIR-VOYAGERS

MAN has always wanted to fly, and for hundreds, perhaps for thousands, of years he has been trying to make a machine to carry him up. Clergymen, bishops, popes have been among such experimenters. Wings, fastened to the shoulders and moved by the arms, proved useful only to break the owner's bones. A certain philosopher seriously suggested that very thin flasks, filled with morning dew, should be festooned about the waist, expecting the heat of the sun to vaporize the dew and so lift the man to the moon. Another person recommended huge sky-rockets, the man to be fastened to the stick and to ascend



THE "FLYING"-FROG OF JAVA.

Sketches from two observers. There are not many reliable records of observations on this frog. All, however, agree that the action of the webbed foot is "flight" similar to that of a flying-squirrel.

with it. But none of these inventors made any provision for coming down, and that is a fatal defect, for it is the stopping so suddenly that is unpleasant.

Modern inventors have been fairly successful with the aëroplane, but for a long time two little animals have used a similar principle in their successful flights. The flying-squirrel and the flying-fish sail through the air, and rise and fall on an aëroplane of nature's invention.

Our common flying-squirrel, with its thin, wing-like membrane stretched tightly between the extended legs, is a typical aëroplane. Thoreau, in speaking of such a squirrel, says: "It sprang from a maple at a height of twenty-eight and one half feet from the ground, and landed easily and lightly on the ground at the foot of another tree fifty and one half feet away. Its flight was not a *regular* descent. It varied from a straight line both horizontally and vertically. It skimmed much like a hawk, and part of its flight was nearly horizontal. There were six trees from six inches to a foot in diameter between the beginning and the ending of its flight, and these it skimmed partly round, and passed through their thinner twigs. It did not, as I could perceive, touch a single twig." Other observers have seen crowds of these little creatures in similar sportive gambols which seem to have no other object than playfulness or the mere pleasure of flight. The movement, however, is not flying as a bird flies, for the membrane that supports the animal is motionless and acts like the parachute of the descending balloonist at the circus.

The wings of the two known kinds of flying-fish are the pectoral fins grown to an enormous size. The kind commonly seen is called the flying-herring and resembles the garpike, as the pictures show. They do not move these fins when flying, but seem rather to float on the wind, such flight sometimes extending, in calm weather, to a distance of "more than an eighth of a mile."

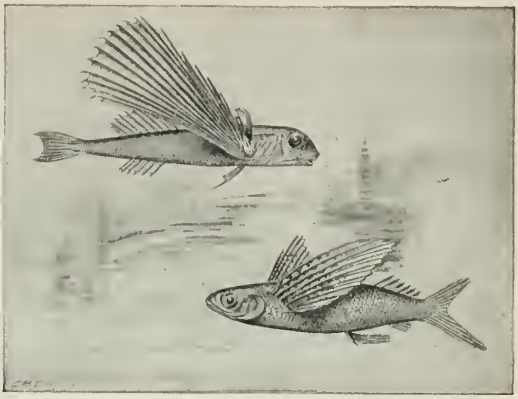
A HYDROPLANE
From the painting by Edgar F. Wittmack

When they come on board a ship, their coming is supposed to be caused by air-currents which the wind makes as it strikes against the side of the vessel, and which lift the fish above the deck. Some observers say that it can change the direction of its flight at will, but it is probably at the mercy of the wind. The fish are supposed to leave the water to escape a hungry enemy.

In Java and some other places, is a remarkable flying tree-frog, with a green back, a white belly, and a bright orange-colored membrane between its toes, which are tipped by circular disks. It, like the chameleon, can change its color to suit its surroundings. It feeds at night on insects, and when disturbed leaps out of the tree and sails away to safety. Some observers call it a frog, while others say it is a tree-toad. The membrane between the toes probably acts as a parachute, and not as a flying apparatus. The toe-disks, like similar enlargements on our common tree-toad, must act like suckers to hold the animal firmly in place against the trunk or the limb.

The so-called "flying" of spiders is explained in another chapter. In favored localities these little gossamer spiders occur in large numbers, and the ground and the herbage are often whitened by the threads that have served their purpose and been thrown away. Just why the spider takes these floating excursions, and why so many are active only in the autumn, are not positively known.

But in Texas another gossamer spider with similar floating habits uses the sailing-webs to carry her young to other places and thus to scatter them over a wide extent of country. This little Texas creature weighs only about two grains, but she spins a hammock-shaped structure of web, cuts it loose when she feels that it has sufficient lifting power, and, with her young ones clustered together on her back, she sails before the wind, apparently trusting to luck to bring her down in a place favorable for her family. Her balloons have been seen floating at a height of from one thousand to two thousand feet, and, before a brisk wind, they may fly for a hundred miles or more.



FLYING-FISH.

The fins are spread out wide and held at rest. They are not used as true wings, but are held out firmly, acting as parachutes, enabling the body to skim through the air.—David Starr Jordan.

None of these contrivances, not even those of man himself, are true flying-machines. They float and sail only because they take advantage of certain natural laws. The human aviator uses an engine to force the machine forward; the squirrels, the frogs, and the fish start by a jump,

THE FLYING-SQUIRREL. THE FLYING-FROG.

In neither of these, as with the "flying"-fish, is there really flight, as a bird flies, by *action* of wings.

THE WRIGHT FLYING-MACHINE IN READINESS.

Men hold the machine till the propellers (eight feet six inches in length) are well in motion. Then it runs along on wheels and runners on the slightly descending ground until it attains speed enough to rise.

and make their descent gradual by the help of a parachute, while the spiders ask the breezes and the currents of warm air to carry their light and naturally buoyant balloons.

CLEMENT B. DAVIS.

WHAT IS MEANT BY "FLYING"

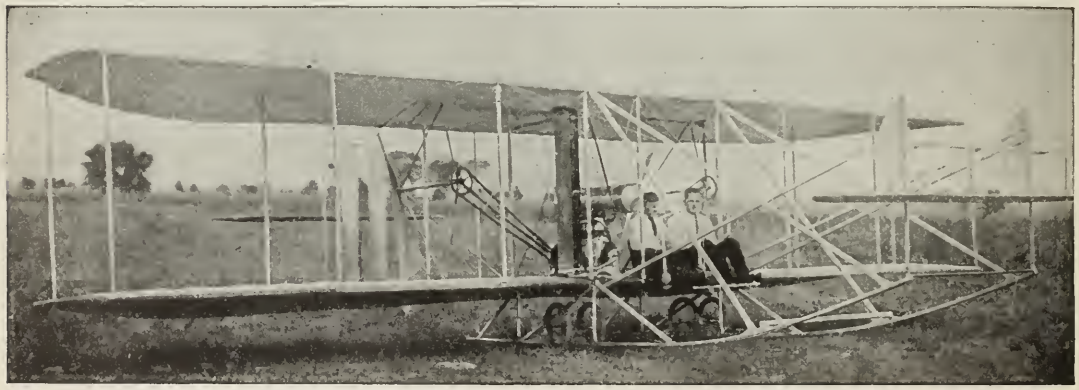
WE are accustomed to think of flying as something bird-like, or as passing through the air by the aid of wings in motion. But when the wings are not flapping, as is often the case with various aërial creatures like the hawk and the dragon-fly, for instance, we think of it, not as flight, but as soaring.

We have also another use for the word to describe the passage through the air of such an object as a kite, an arrow, a dandelion "balloon," or the sailing of October spiders, in which, as will be explained to you, the "flight" is in reality only a blowing about by the breeze acting on the fine filaments that the spider spins for the purpose.

Few of us really mean what we say when we refer to our gentle little friend, the flying-squirrel, as a *flying* animal.

The frequent use of the word "flying" and the prominence given to it in connection with the aëroplanes first successfully employed by the Wright brothers have been of service in turning our thoughts to the sailing, soaring, and flying movements of the lower animals, especially of those that have no true wings, yet use the air as a means of aërial journeying at their own will or at that of the wind.

The operator of an aëroplane is referred to as the aviator, or "man-bird," from the Latin word *avis*, a bird; yet in reality the movements of the machine have only a remote resemblance to those



THE WRIGHT MACHINE RUNNING ON THE SMOOTHLY DESCENDING GROUND.

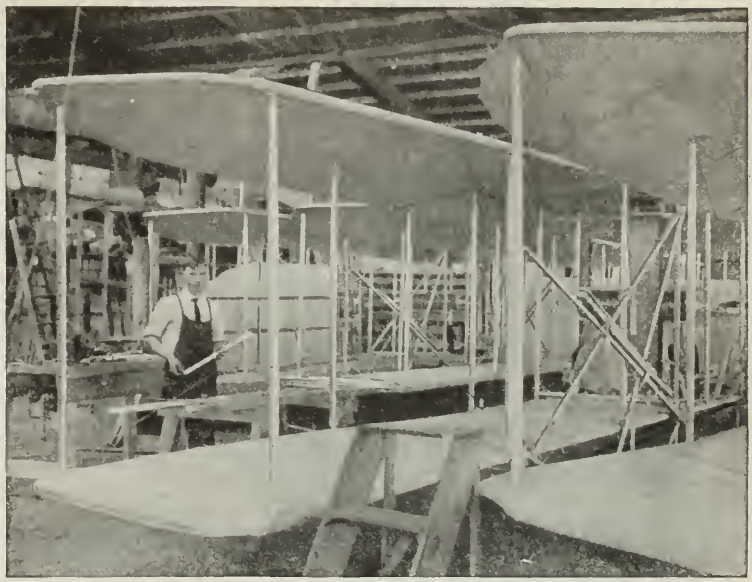
The total weight is about eight hundred pounds in addition to the operators, making over a half-ton to rise in the air.

of a bird. With all honor to that wonderful invention, the so-called flying aëroplane, let us not forget that there is no such creature as a man-bird, and that *man has not yet learned how to fly*—as *birds* fly—in spite of the fact that large sums of money and much time and skill have been used in his efforts to make a machine that will travel through the air by the movement of wing-like parts.

The aëroplane may be best understood if it is regarded as a kite and a motor-boat combined, and not as a machine for flying. We all know how a kite, especially one of the "box" form, will tug at the string, or will support a weight, such as a flag or an advertising sign, in mid-air. A box kite may easily be imagined or even be made large enough to carry a boy or a small man in a strong and steady wind. But the practical difficulty would be in launching such a kite into air and in controlling its motion. Indeed, a glider is theoretically such a kite kept near the ground. The flying-machine is really a glider controlled and propelled by its own engine; or, in other words, it is a motor-boat moving on the air instead of on water; and as the tendency to sink on air is greater than on water, the aëroplane has to be propelled at a high rate of speed against slightly inclined rudders and with broad stretches of supporting planes.

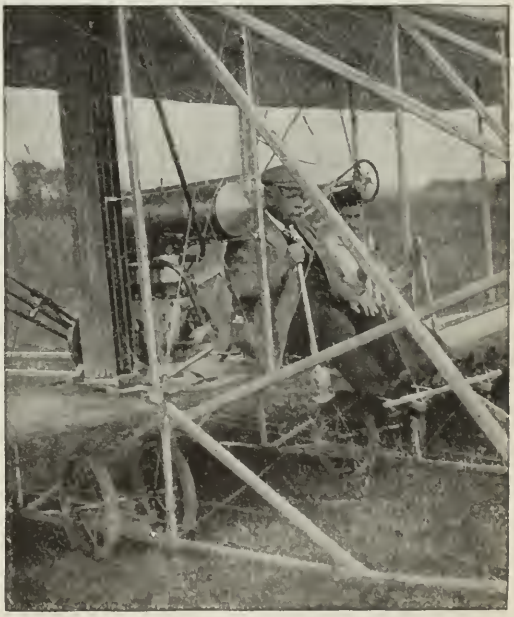
The aëroplane is therefore an air-boat rather than a flying-machine. The only action of the bird that it imitates is the bird's soaring, in nearly the same sense in which a boat floats or a duck swims. With the duck, however, there is one difference. It shares the balloon principle, because its body will not sink when it stands still, whereas the aëroplane will fall unless it is constantly urged forward. The duck is lighter than its bulk of water, as the balloon is lighter than its own bulk of air. To call an aëroplane a flying-machine, is therefore exactly the same as to call a boat a swimming-machine (keeping in mind the swimming of the duck and neglecting that of fishes and of human beings).

The aëroplane is a propelled box kite or "glider." It has not even yet learned how to "fly" in the sense of soaring, because the hawk can hover almost if not quite motionless, sustained probably by ascending currents of air, while the flying-machine begins to fall as soon as the propelling power is discontinued.

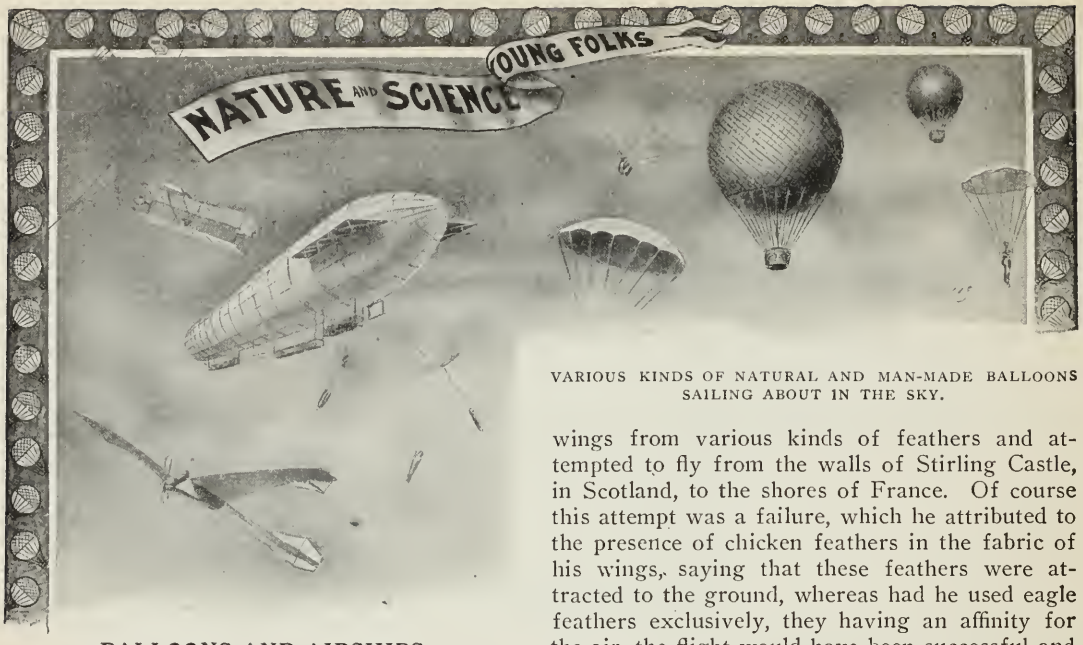


THE ASSEMBLING ROOM AT THE FACTORY OF THE WRIGHT COMPANY.

The word aëronaut, from two Greek words meaning air and sailor, is preferable to aviator.



TAKING INSTRUCTIONS IN THE MANAGEMENT OF A FLYING-MACHINE.



VARIOUS KINDS OF NATURAL AND MAN-MADE BALLOONS SAILING ABOUT IN THE SKY.

BALLOONS AND AIRSHIPS

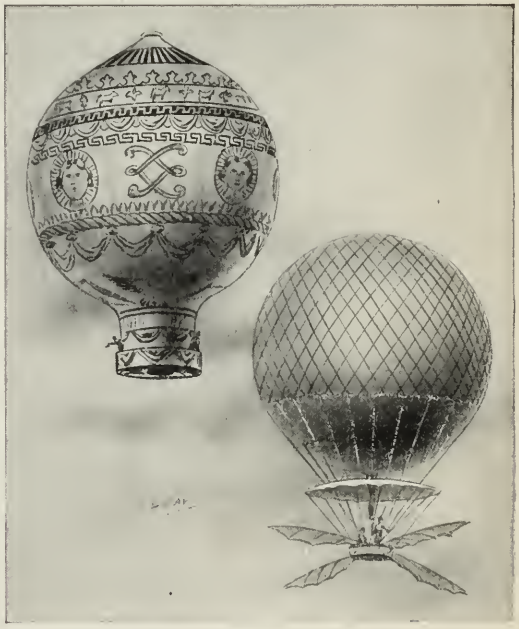
MADE BY MAN IN FANCY AND FACT

Probably the first mention of human flight is the story of the mythical Athenian Dædalus, who made himself and his son each a pair of wings of feathers fastened together with wax. By means of these, so runs the fancy, they escaped from an island on which they were imprisoned by King Minos. In the joy incident to the exercise of this new power, Icarus, the son, flew too high, in spite of the advice of his father. The heat from the sun melted the wax that fastened his wings together, and he fell into the sea!

The germ of fact on which this myth is founded is the probability that Dædalus used sails, which up to this time had never been known. Quite naturally he outdistanced the king's pursuing galleys, which were equipped only with oars.

During the darkness of the Middle Ages common superstition credited every one at all distinguished in the science of physics with the power of aërial flight. A vestige of this superstition remained into the last century, when the so-called witches were likewise accredited with the power of flight through the air, and are pictorially represented usually as mounted on a broom.

In the early part of the sixteenth century, during the reign of James IV, we pass from fancy to fact and have real names and dates. Quite naturally the first attempt at flying was by means of wings in imitation of the birds. At this time an Italian alchemist constructed himself a pair of wings from various kinds of feathers and attempted to fly from the walls of Stirling Castle, in Scotland, to the shores of France. Of course this attempt was a failure, which he attributed to the presence of chicken feathers in the fabric of his wings, saying that these feathers were attracted to the ground, whereas had he used eagle feathers exclusively, they having an affinity for the air, the flight would have been successful and so he would not have fallen and broken his leg!



THE GAUDILY DECORATED BALLOON OF THE MONTGOLFIER BROTHERS AND THE ONE USED BY BLANCHARD.

Note the parachute on this one as a safeguard in case of the collapse of the balloon; also the wings for protection.

Next came the ridiculous idea of bringing down a bag full of the thin ethereal substance which

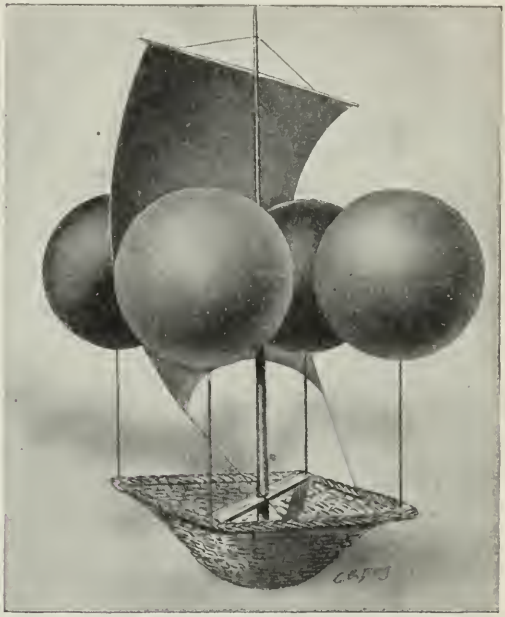
floats above our atmosphere. The difficulty of procuring any of this substance of course prevented its trial. An idea along this line, no more practical but showing an advancement in science, was the proposition, in 1670, by Francis Lana. This idea was to construct four large copper balls of very thin material, exhaust the air from them, and fasten them to a suitable car. There being no air in these balls, they would be lighter than the surrounding air and would naturally rise. The difficulty in this case would have been to prevent the balls from collapsing.

The first practical idea of the balloon originated more than a hundred years later, when the Montgolfier brothers, noticing how smoke rose upward into the air, conceived the idea of filling a bag with smoke. The development of this idea resulted in the construction of the first hot-air balloon in June, 1783. This consisted of a spherical cloth bag about thirty-five feet in diameter and inflated over a fire fed with bundles of chopped straw. The next step was the use of hydrogen gas, and the balloon was practically invented as used to-day. The use of this gas was the idea of M. Charles, a professor of natural philosophy at Paris. All the features of the modern balloon as now used are practically due to him, including the valve at the top and suspending the car from a network surrounding the balloon. His first balloon rose rapidly to a height of about three thousand feet. It came down shortly and landed in a field, where the terrified peasantry tore it to shreds.

The first balloon to carry living freight was in September, 1783, when Joseph Montgolfier sent up a sheep, a duck, and a cock, all of which landed safely. This balloon, as seen in the picture, was very gaudily decorated. The first human being to ascend in a balloon was a young French naturalist, M. François Pilâtre de Rozier, who used a captive balloon for his first attempts. Then on November 21, 1783, he and the Marquis d'Arlandes made the first trip in a free balloon. This was made in a hot-air balloon, and fire was kept burning in a brazier suspended beneath while up in the air.

Balloon ascensions have always attracted a great deal of attention. It is related that in 1784, when Lunardi, who was the aërial hero in England, made an ascension, a criminal was on trial. He was about to be convicted, but, to save the time of further argument, he was acquitted in haste, so that the court could view the balloon. The king was also in discussion with his ministers. On hearing that the balloon was passing, he adjourned the meeting, remarking that they might resume their deliberations but might never see Lunardi again. Most of us lately saw in one of the circuses a woman sitting on a horse which was standing on a platform suspended from an imitation balloon, which was then drawn to the top of the tent. This act, thrilling as it was, can scarcely compare with the original, in which a Mr. Green made a real ascension astride his pony in this manner.

The limitations of the gas-bag type of airship have caused numerous experiments with the sail-



THE IDEA OF FRANCIS LANA, 1670.

He proposed constructing a number of huge copper balls, exhausting the air from them to make them light, and attaching a car to them. Of course his idea was impractical.

ing or gliding type of flying-machine. At first these were sailed like a kite, with the string fastened to an automobile, which was speeded away. The sailing device rose into the air or not according to the success of the designer. When the fact was ascertained that these machines would ascend and carry a man, the towing automobile was abandoned and the machine itself was equipped with a high-powered gasolene engine to run a propeller. This line of experimenting resulted in the modern aëroplanes with which we are all familiar.

BALLOONS MADE BY NATURE IN PLANTS AND ANIMALS

Man's progress in the invasion of the realm of the birds is more than marvelous, but he is not alone in this competition. Compared with the hosts of tiny airships sent up by every field and meadow, he is but a novice. Heavenward they go

with every breeze that blows, from early spring, when the willow, the cotton-tree, and the dandelion send forth their downy swarms, until the snows of winter drape the landscape—catching, per-

A VANISHING TRAIL OF THE NATURAL MEADOW BALLOONISTS.

Showing among them a human aëronaut hanging from his parachute.

chance, the last fledglings of the common dandelion. These tiny, inanimate balloonists were veterans in the art long ere man existed, and well may he study some of their devices. How like, indeed, is he, descending in his parachute, to some of these ballooning seeds! In our picture he is placed among a drifting trail of these various tiny aëronauts, which vanish in the airy distance. See how naturally he fits in and harmonizes with the others, an atom among atoms, with merely a different form of pappus, or tuft of down, each freighted with its living tip. Any playful wind-gust down the country road sends thousands of these little wandering airships in tiny dusty eddies upward from the sunny fence corners. Among this scurrying family of aërial voyagers the members of the great composite and the chicory families, "veritable children of the breeze," will usually predominate. After frost, though, the silken-tufted milkweeds lend their liberal quota. The cattails, the "hardy Norseman" of these air voyagers, find the icy gales of winter their favorite sailing-times, and they leave the dried and fluffing head in clouds.

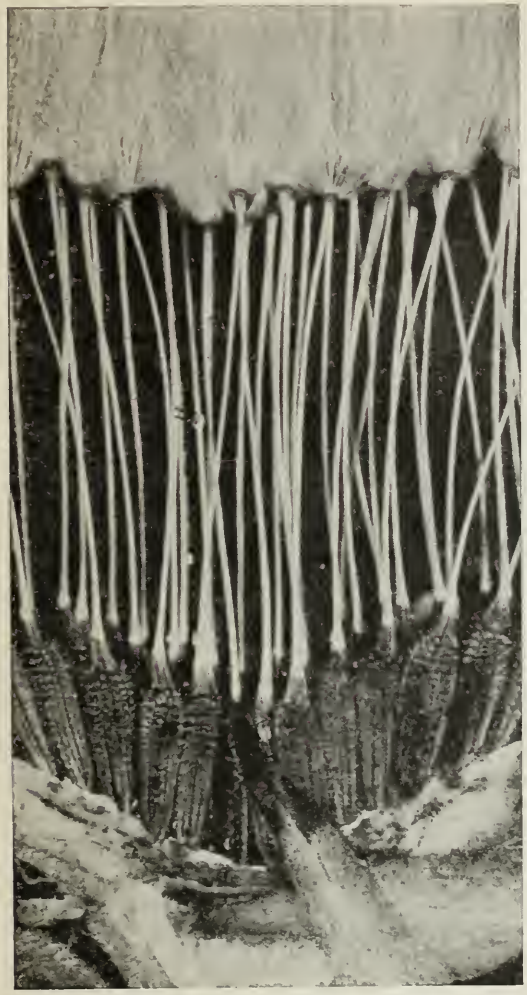
Ascending among this airy fraternity during early fall, you may perchance notice a slender bundle of a few long, glistening, silky strands, loosely gathered together about their middle, leaving their free ends flying in the wind, waving upward from their weighted center. You might make many fruitless guesses as to what this queer seed is, and be wrong each time, for it is no seed, but a tiny animal. It is one of the little araneid balloonists. These tiny spiders were not caught

THE SPIDER BALLOONISTS.

On the leaf the one to the left is almost ready to depart. The one next to him has just sprung off. The one in the air a little to the left of these has just started. Note the position. The highest one and the one next, to the right and a trifle below, are in the attitude of smooth sailing. The last one to the right is taking in sail and is descending. Note the little pellet held by his legs. In the panel are shown some tiny flies entangled in the web. They are merely entangled, and not stuck by the viscid drops as with the cross lines in the common orb web of a spider, for these strands have no viscid drops.

in the wind accidentally, but their flight was intentionally and deliberately planned. The Rev.

Dr. McCook, the Boswell of the spider fraternity and from whom they have kept but few of their



A PEEP INTO A DANDELION HEAD.
By the aid of a pocket magnifier showing each "balloon" with its "basket" (or seed) ready to start.

secrets, says that these little fellows climb to the tops of weeds, twigs, and, what seems the favorite place, the tops of fences, for their flights. He says that September is a good month to witness these spider flights, though October is a better time. The practice is about as follows: the little spider climbs to the highest point and faces the wind. It then elevates its body to an angle of about forty-five degrees, and stiffens the legs so as to stand as high as possible. From the spinnerets a single thread or ray of threads is spun, and is drawn out by the wind to a distance of several feet. When enough web has been let out, the force of the wind upon it draws hard on the spiderling, who then lets loose all feet suddenly, and apparently springs into the air, and floats away, usually back downward. In most cases the body is then turned round so the head faces the way in which the wind is blowing. Meanwhile a ray of threads is spun out, and the spider now hangs from a little framework suspended from long, buoyant streamers ascending from each end. When the spider wishes to descend, it draws in the forward ray, rolling it into a little pellet held close to its body.

These little fellows ascend to great heights and travel many miles. Mr. Darwin noticed them at

THE "AIRSHIPS" OF THE CLEMATIS IN FLIGHT.

a distance of sixty miles from land, and they have also been reported more than two hundred miles offshore.

A BIRD (RED-TAILED HAWK) IN FLIGHT.

As seen from below and rear. Note the great expanse of wings and tail for resisting, that is, floating on, the air, as seen in the central figure; then in the figure at the left, the thin, air-cutting edge of a bird as seen from front or rear.

HOW A BIRD FLIES

THOUGH there are many internal peculiarities, as of lungs and of bones, by which birds are adapted to flight, they are neither the main things nor the most interesting things to be considered when we inquire into the how and the why of the flight of birds. In observing the flying bird, how far does

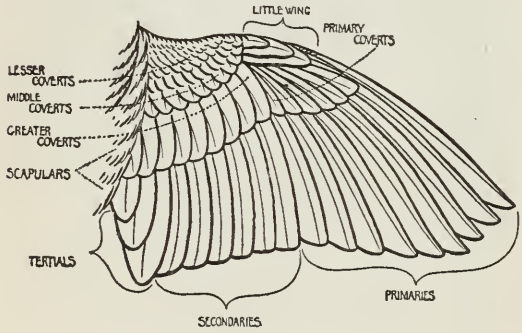


FIG. 1. A SPARROW'S WING SHOWING THE DIFFERENT SETS OF FEATHERS.

flight explain itself? In other words, what can live birds teach us human beings of flight?

The general form of the bird is naturally the first thing of which we think. We easily notice that in wings and tail it is kite-like; in body and head, bullet-like. So important are these simple discoveries that this essay might with some reason be ended here. Imagine a kite with a rudder and having an intelligent will of its own. Is it not possible to think of it as moving about in the air with a degree of bird-like freedom?

As for the bullet-like form of head and body, one can see by a glance at Fig. 2, especially *d*, these appear to be practically a point, which we may call the point of will. The head is indeed the will-point in the bird-kite. In flight it bears outwardly the same relation to the bird's body that the prow of a boat does to its hull; it cleaves the air as the boat's prow does the water.

Let us look at some apparent exceptions to our ruddered kite moving by its own will. In the same diagram (*b*) notice that the head and body of a grouse is, for example, a pretty bulky point of will! But remember, too, that the flight of such birds is remarkably heavy and limited both in direction and duration. There is quite as much difference between the easy, graceful, sweeping, tireless flight of a man-of-war bird and the direct,

labored, short spurt of a grouse as there is between the relative size or expanse of their wings.

The rules are:

Birds capable of very prolonged, graceful, varied, soaring flight have a vast expanse of wings as compared with the size of the body. Birds of short, labored, and bullet-like flight have

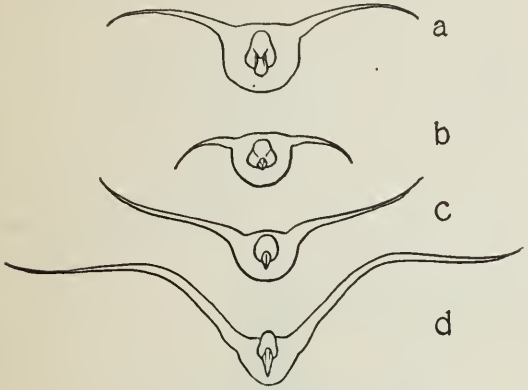
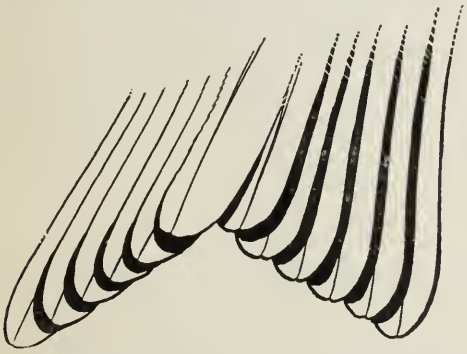


FIG. 2. THE "CUTTING EDGE" OF A BIRD.

To show the small resistance to the air in the direction of flight. a, wild duck; b, grouse and quail; c, crow; d, man-of-war bird — a typical sea-bird.

comparatively small, rounded wings and heavy bodies. When the flight is between these extremes, the extent of the wings as related to the size of the body remains the same with relation, again, to the degree of freedom in the bird's flight. Birds with poorly developed wings—for example, the ostrich, penguin, and apteryx—are always flightless.

If we believe the form of a bird, such as we



THE DETAIL OF THE END OF A BIRD'S TAIL.

To show shutter-like lapping of the feathers. Note the arrangement of the feathers in pairs, the outermost feather on each side being the outer pair; hence there is always an even number of tail-feathers—usually twelve.

have seen it to be, of first importance, we should expect to find on closer examination that every detail of its make-up goes to prove the fact, and this is exactly what we do find, as shall be seen.

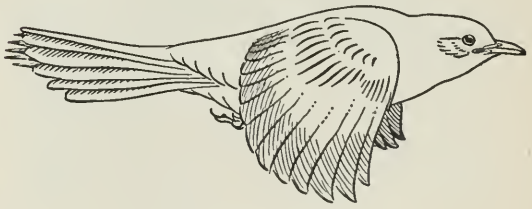
In Fig. 1 notice the sets of feathers marked "primaries" and "secondaries." This is the order of their importance in flight, the primaries being the all-necessary ones, since a "pinioned" bird (one suffering the permanent loss of several of the outermost, or all of these feathers) cannot fly, though it may fly when most of its second-

A TYPICAL BIRD IN FLIGHT.

To show loose overlapping of the flight-feathers that the air may escape between them in the *upward* stroke of the wings.

aries, and even all of its tail-feathers as well, are alone missing. We see among all birds a general sameness of the wing-feathers of the outer set; with few or no exceptions, they are comparatively strong and stiff and of one general shape, while the other feathers differ, among the various kinds of birds, in endless and often extreme ways. This fact very properly leads us to believe the typical shape of these primaries must be the best for the purpose of flight.

Flight-feathers are found to be stiffest and strongest at their quill ends and most yielding at their tips. They always overlap in the same way, the outermost feather of the extended wing being the undermost in the fully closed wing. The shaft of the feather is near the middle, but toward the outer edge in the inner flight-feathers, and near the outer edge of the outermost feathers.



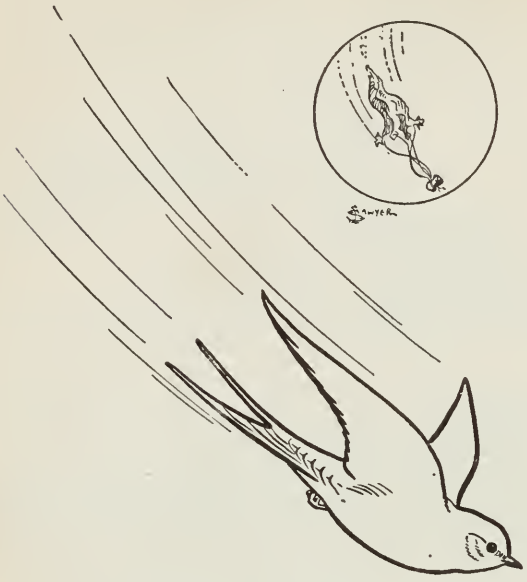
A TYPICAL BIRD IN FLIGHT.

To show the tight overlapping of the flight-feathers, to resist the air, in the *downward* stroke of the wings.

By these arrangements the wing has a valve-like and an oar-like action upon the air, according, more or less, to the will and purpose of the bird whether to sail, swoop, stop, go ahead, or what not. Moreover, the feathers are so arranged in sets, one set to each joint of the wing, as to fold and overlie with remarkable smoothness.

In these respects and in a great many others,

we see that the wings resemble oars, rather than sails, for navigating the airy sea. However, "fish of the air" is a still more scientific title for



A BARN-SWALLOW IN FLIGHT.
Showing the use of the wings and the tail in swooping.

birds than "ships of the air"—even when we stretch "ships" to mean submarines.

That the tail of a bird serves mostly as a rudder and a brake is evident when we watch a sparrow which has lost this means of steering and arresting its flight. It is apt to fly only straight forward, and it comes to rest awkwardly—more so than birds whose tails are naturally very short or almost wanting. The latter class of birds usually have the wings placed far backward, as in loons, ducks, and geese; or they have long legs which they carry extended behind them like a tail, as in herons and snipe. The feet and legs of such birds doubtless serve the ordinary purposes of a tail. In coming to rest a wild duck, for example, drops its feet and stretches its webbed toes apart in a conspicuous fashion, just as a meadowlark expands and drops its tail. Herons and snipe make a similar use of their legs, the length of the latter probably making up for the lack of webbed toes in resisting the air.

SHOWING THE USE OF THE WINGS AND TAIL IN STOPPING.

The relative importance of wings and tail is further shown by comparing these organs in all cases where they are modified as ornaments. In doing this, we find the tail is of an ornamental

A SCISSOR-TAILED FLYCATCHER.
One of the common instances in which the tail-feathers are lengthened as ornaments.

form far oftener than the wings. With many birds the tail is really a hindrance to flight.

In Africa Mr. Roosevelt observed that the long-tailed male whydah finches were slower than their mates, whose tails were of the usual length, so that the males fell behind when a flock took wing.

Among the pheasants such ornamental tails are of common occurrence, and there are numerous examples among other families of birds. Perhaps

any greater development of tail than in our common barn-swallow should be regarded as more ornamental than useful.

If we turn our attention now to the wings of birds, we shall look in vain for anything like such

THE PENNANT-WINGED NIGHTJAR.
One of the rare instances in which the flight-feathers are lengthened as ornaments.

numerous and embarrassing shapes. So rarely do such modifications of wings occur that I can think of only one striking example among the birds of the world—the pennant-winged nightjar, a kind of night-hawk of the tropics. It is interesting to note this bird is a night species, probably with very few, if any, enemies to make strong flight necessary.

Thus we have seen that the tail is not even strictly necessary to flight, though the tails of flightless birds are commonly, if not always, very small or almost wholly wanting, and the birds of the best powers of flight have, as a rule, the best-developed tails, whereas quite well-developed wings are decidedly necessary to flight.

EDMUND J. SAWYER.

FLYING-FISH

INTERESTING are the habits of the flying-fish, that queer denizen of the sea, found principally in the region of the trade-winds. Does it rise from the sea like a bird? you ask. No; it shoots out of the waves like an arrow, and with outspreading wings sails on the wind in graceful curves, rising sometimes, one might say, to the height of fifteen feet, but not often so high, and then lowering, it again touches the crest of a wave and renews its flight. This operation may be repeated till it covers a distance, say, of five hundred yards, in the case of the stoutest on the wing, though very often not half that distance is covered. A ship sailing through the trade-winds will often be visited, on dark nights, by flying-fish which hit the sails or rigging and fall on deck, where, of course, they soon give up life. Captain Joshua Slocum, who made a voyage round the world, says:

On my voyage in the *Spray* I was often supplied in this way by all the fish I wanted for my table. They were palatable and nutritious. They go by single individuals, or dart out in schools or flocks of hundreds to clear a ship's prow or escape a pursuing enemy. It is said that the life of a flying-fish is a most unhappy one, spent in eluding the tigers of the sea on one side, and birds of prey on the other. However this may be, I have never yet witnessed the capture of one by even fish-hawk or gull. Its wings, of the most delicate film, are webbed on ribs of exquisite design. If you watch them closely when they touch a wave you will see their wings vibrate when they work at all. It requires a keen eye to detect the movement. The lower lobe of the tail of the flying-fish extends well downward, low, so that with ease it can strike a new course the instant it touches a wave where a hungry pursuer may be ready to receive it with open jaws. One of the joyful sights on the ocean, of a bright day, is the continual flight of these interesting fish.

THE CALIFORNIA FLYING-FISH.

The numerous species are of different sizes, the smallest only six inches, the largest, the California flying-fish, eighteen inches.

THE WORLD'S FOOD

SOME PARTS OF THE WORLD MUST FEED OTHER PARTS

Let us now think of those conditions that make it necessary for people in some parts of the world, or of a country, to produce food for people in other places.

We know that manufacturing—the making of things—is necessary for a nation, and that the more workers there are in its manufactures the more a nation needs to increase its food-supply. And this is something that concerns all the manufacturing people in the world. This demand for food by such people also affects industry in every part of the world that is capable of supplying it. The same demand is likewise made by all commercial people—those who buy and sell things that other people make—and, in fact, by all who are engaged in any other than food-producing occupations. So the prosperity of manufacturing industries and of trade means prosperity for the food-producing regions of the earth.

THE ZONES AND THEIR PRODUCTS

Let us remind ourselves that the world is divided into five zones: the torrid, the north and south temperate, and the north and south frigid zones.

The north and south frigid zones contribute little to the food-supplies of the world, all vegetation except lichens and mosses being unable to withstand the intense cold. The reindeer is the only food-supplying animal that exists in this region, but the arctic fox, the polar bear, and the seal supply us with fine furs, while the whale affords oil and whalebone.

The products of the temperate and torrid zones differ greatly in character. They are divided into tropical (belonging to the torrid zone), subtropical (that is, nearly tropical), and temperate, according to the character of the climate in which they thrive best.

It is well to remember, however, that climate does not vary exactly with lines of latitude, owing to the influence of elevation, currents, etc., and that therefore the limits of these areas are more closely related to the lines of equal temperature than to the lines of latitude.

Of tropical plants the palm may be taken as the typical example, while the vine and wheat will stand well as types of the subtropical and temperate plants respectively.

GREAT FOOD-PRODUCING REGIONS

In food-producing areas North America is very rich, and stretching as it does through the three regions, tropical, subtropical, and temperate, its products are as varied as they are vast in quantity. The virgin lands of Canada, and in our own country such States as Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, North and South Dakota, Ohio, Pennsylvania, and the States of the Pacific coast are great centers of wheat-production.

In recent years the United States has produced fully one-fifth of all the wheat grown in the world. Thus in 1909 the world's production was 3,624,418,000 bushels, of which this country produced 737,189,000 bushels. Russia in Europe came next with 711,479,000 bushels, every other country being far behind. More than one-half of the world's crop was produced by European countries.

Maize or Indian corn is also largely grown in the United States. Rice is produced in considerable quantity in Louisiana, South Carolina, Georgia, and other Southern States. Louisiana also produces annually several hundred thousand tons of cane-sugar.

We get immense supplies of beef from the cattle-ranches of the West and Southwest, and pork is abundantly supplied from the great Western regions through Chicago, Kansas City, St. Louis, and other commercial centers.

The Argentine Republic, in South America, is steadily developing its great possibilities as a food-supplying country, and wheat, mutton, and

beef are exported through its principal seaport, Buenos Aires. Brazil, with a more tropical climate, exports from Rio de Janeiro large quantities of coffee.

Australia is another young country which has advanced itself until it has become important among the food-supplying countries of the world. Australian wheat, mutton, and lamb are exported in larger quantities from year to year. Tasmania supplies the English market with fruit equal to the best that England herself grows. The Canterbury lamb of New Zealand is sold everywhere in Great Britain.

India stretches through both the tropical and subtropical regions of the world, and owing to its plateau in the Deccan and the gradually increasing elevation from the Ganges valley to the crests of the Himalayas, it is also able to grow many of the products of the more temperate regions. Thus tea and rice are grown along or near the Ganges valley, and wheat is exported from the northern parts. Millet is also grown.

The island of Ceylon, which is within a few degrees of the equator, grows tropical plants, and tea, coffee, and spices are its most important exports.

With the exception of tea from China, and the famous mocha coffee from Arabia, the rest of Asia is not an abundant source of food-supply. The thickly inhabited areas of Japan and China consume all that they can produce, while the long stretch of steppes which forms the southern portion of the Russian territory in Asia gives subsistence to wandering herds of cattle and sheep.

The European countries bordering on the Mediterranean produce the subtropical fruits, such as the olive, grape, orange, citron, and fig, while the parts of Russia bordering on the Baltic and Black seas are great wheat-growing districts. Hungary also is an agricultural land, producing cattle, sheep, and wheat for export.

Africa has not yet developed its resources in this direction, though Egypt has long been famous as one of the granaries of the world. This fame, as you know, it has been able to gain and keep owing to the annual overflowing of the Nile. The famous dam across the Nile at Assuan, just below the first cataract, was built to regulate and secure this annual beneficent overflow.

Even in agricultural areas, and regions with agricultural possibilities, the inventor and the engineer have not been idle, but by improvements in agricultural machinery, by schemes of irrigation, as in the arid parts of our country, in India, and in other lands, they have done much to extend and cheapen the work of the farmer, upon which so much of general welfare depends.

THE FOODFUL GRAINS

Among the most important of our foodstuffs are those furnished by the edible grains that we call cereals—from the plants that yield them, which are so named after Ceres, the Roman goddess of agriculture. These plants are also called corn-plants, and sometimes bread-plants. Among the principal cereals or grains of the world, we will speak particularly of those most largely cultivated and most widely used for human consumption.

BARLEY

Of this very important genus (*Hordeum*) four species—or at least varieties—are enumerated. It has many subvarieties, and new kinds are continually introduced. That most cultivated is *Hordeum vulgare,* or the common barley. The most hardy of all cereal grains is barley, its limit of cultivation extending further north than that of any other; and at the same time it can be profitably cultivated in subtropical countries. The opinion of Pliny, that it was the earliest food of mankind, appears to be well founded, for no less than three varieties have been found in the lake-dwellings of Switzerland, in deposits belonging to the Stone Age. *Hordeum hexastichum sanctum* is both the most ancient of these varieties and the most commonly found, and is the sacred barley of antiquity, ears of which are frequently represented plaited in the hair of the goddess Ceres, besides being figured on ancient coins. The cultivation of barley in ancient Egypt is indicated in Exodus ix. 31. Till within recent times barley formed an important source of food in northern countries, and barley cakes are still to some extent eaten. Barley is a very nutritious substance, the salts it contains having a high proportion of phosphoric acid, and on it the Greeks trained their athletes. Barley is now chiefly cultivated for malting, to prepare spirits and beer, but it is also largely employed in domestic cookery.

During many years the production of barley in the United States has steadily increased. The product in 1866 was 7,916,342 bushels; that of 1909 was 170,284,000 bushels.

MAIZE, OR INDIAN CORN

Generically the term corn includes all grains used for food. In different countries the name is given to the chief breadstuffs—in Scotland usually to oats; in England to wheat, or to wheat, barley, rye, and oats collectively; in America to maize (Indian corn), the cereal peculiar to the western hemisphere. Belonging to the order of *Graminæ*

or grasses, Indian corn is known in botany as *Zea mays*. It is unknown in its native state, but is most probably indigenous to tropical America Small grains of an unknown variety have been found in the ancient tombs of Peru. Some authorities, however, believe that maize came from Asia, and it was said by Santa Rosa de Viterbo to have been brought by the Arabs into Spain in the thirteenth century.

A drawing of maize has been reproduced from a Chinese work on natural history (*Li-chi-tchin*, 1562). Maize is not figured on Egyptian monuments, nor was any mention made of it by Eastern travelers in Africa or Asia prior to the sixteenth century. One of these, however, declares that it had been cultivated from a very ancient period in the Asiatic islands under the equator, and that it was received thence into China, and so passed westward into India and Turkey, hence its name of "Turkey corn," under which title John Gerard, the English herbalist, in 1597 figured and described seven kinds, as well as one called "Corne of Asia." Gerard and others think that it first came from the East, but that on the discovery of America it was reintroduced into Europe from that country. Gerard observes: "These kinds of graine were first brought into Spaine, and then into other provinces of Europe out of Asia, which is in the Turkes Dominions; as also out of America and the Ilands adioyning from the East and West Indies and Virginia, etc." Humboldt and others, however, do not hesitate to say that maize originated solely in America. It had been long and extensively cultivated here at the period of the discovery of the New World.

More than three hundred varieties of maize are known, and they differ among themselves more than those of any other cereal. Some come to maturity in two months, others require seven months; some are as many feet high as others are inches; some have kernels eleven times larger than others. They also vary in shape and size of ears, color of the grain, and in chemical composition. With the native American Indians, "green corn" was an important food, and its season was celebrated with festivals. Equally valued is it by the present peoples of the American continent. It is a very nutritious food, being richer in albuminoids—calculated in the dry weight—than any other cereal. It can be grown in the tropics from the level of the sea to a height of thousands of feet, and in the south and middle of Europe, but it cannot be grown in Great Britain with any chance of profit, except perhaps as fodder. Frost kills the plant in all its stages and all its varieties; and the crop does not flourish well if the nights are cool, no matter how favorable the other conditions. Consequently it is the first crop to disappear as one ascends into the mountain regions, and comparatively little is grown west of the great plains of North America. It prefers a deep, rich, warm, dry, and mellow soil, and hence the rich bottoms and fertile prairies of the Mississippi basin constitute the region of its greatest production.

As an article of food Indian corn is one of the most extensively used grains. When it is sown broadcast, or closely planted in drills, the ears may not develop at all, but the stalk is richer in sugar, and this fact is the basis of growing "corn-fodder," of which the possible production per acre is enormous. On the treeless Western prairies corn has often been grown for fuel, one hundred bushels of ears being reckoned equal in heating-power to a cord of the best hard wood, and this quantity may be grown for a price less than a cord of hard wood brings in the large cities. The use of corn in the industries, as the raw material for the manufacture of alcohol, starch, glucose, oil, and various food products, increases year by year, with the increase of facilities for production and the increasing applications of chemistry to the arts.

In the United States the area of corn-planting now annually embraces an average of about 80,000,000 acres, and corn is the chief grain-crop, and is far larger than that of any other country. It was 2,772,376,000 in 1909. Though corn is more extensively used as food in the United States than in any other country, only a small percentage of the total crop goes for human consumption.

OATS

Various grasses of the genus *Avena* are known to us by the name of oats. The origin of the cultivated oat is referred to *A. Fatua,* "wild oat." The bristle-pointed oat (*A. Strigosa*), perhaps the original of the Scotch oat, was cultivated in early times in England and Scotland, both in its white and its black varieties. Many varieties of the cultivated oat are now grown in different parts of the world.

According to good authorities this cereal was not cultivated by the Hebrews, Egyptians, ancient Greeks, or Romans. Central Europe appears to be the locality where it was cultivated earliest, at least in Europe, for grains have been found among the remains of the Swiss lake-dwellings perhaps not earlier than the Bronze Age, while Pliny alludes to bread made of it by the ancient Germans. Galen's observation is also recorded, that it was abundant in Asia Minor, especially

Mysia, where it was made into bread as well as given to horses. It is likewise stated that ten varieties were introduced by Mohammed Ali into Egypt for fodder, and that it was seen by Bruce wild in Abyssinia, sometimes tall enough to conceal horse and rider. Eastward from Syria it is called "sulu" by the Tartars, and it was observed by Kaempfer and others in Japan. It is said to have been brought over to America by colonists.

Besides the use of the straw when cut up and mixed with other food for fodder, the oat-grain constitutes an important food for both man and beast. Being cultivated best in comparatively low temperatures, it has long formed the staple food for Scotland, north England, and Derbyshire, as well as for Germany, wherever wheat does not flourish. It is extensively grown in all the Northern States of the American Union, and in New England its production largely exceeds that of wheat. The oat-grain (excepting the naked oat), like that of barley, is closely invested by the husk. This latter is used both in Scotland and Wales for the preparation of a kind of porridge, called sowans and sucan. Oatmeal is made from the kiln-dried grain from which the husks have been removed; and the form of the food is the well-known "porridge." In Ireland it is mixed with Indian-corn meal and is called "stirabout." Groats or grits are the whole kernel from which the husk is removed. Their use is for gruel, which used to be consumed as an ordinary drink in the seventeenth century at the coffee-houses in London. The meal can be baked into cake or biscuit, as the Passover-cake of the Jews; but it cannot be made into loaves in consequence of the great difficulty in rupturing the starch-grains, unless the temperature be raised to a considerable height.

Among grain-crops in the United States that of oats is growing in importance. In 1909 the production amounted to 1,007,353,000 bushels.

WHEAT

Of all cereal grasses the most important as well as the most diffused is wheat, an annual plant (*Triticum*) of which there are many varieties, and whose grain is the staple food of more people than that of any other cereal except rice. Next to Indian corn, it is the most productive of all the cereal grasses. The original home of the plant is supposed to have been in Western Asia near the Mediterranean, and from that region its cultivation is believed to have extended in very early times to China on the east and to the Canaries on the west. The Chinese claim that they cultivated it as early as 2700 B.C., and in Egypt, where its origin was attributed to Isis—as by the Greeks it was ascribed to Ceres—it appears to have been used as food at a still earlier date. Little is known of its introduction into Europe, where now it is the breadstuff of all the greater nations. It is used to a considerable extent in India.

In the western hemisphere wheat was not known till the sixteenth century. Humboldt mentions that it was accidentally introduced into Mexico with rice brought from Spain by a negro slave belonging to Cortés, and the same writer saw at Quito the earthen vase in which a Flemish monk had introduced from Ghent the first wheat grown in South America. In various parts of the world—North and South America, Australia, and perhaps Siberia—great wheat-lands yet remain to be developed. When they are cultivated large additions will be made to the world's crop. In the United States, wheat, in area and value, ranks next to corn.

Ordinarily, on account of its high price, wheat is not used as animal food, but when its cost has permitted such use it has proved equal to other grains as a basis of animal products.

RICE

According to high authorities the cultivated rice with all its numerous varieties has originated from a wild plant called in India Newaree or Nivara (*Oryza sativa*). It is also native in tropical Australia. Rice has been cultivated from time immemorial in tropical countries. According to Stanislas Julien a ceremonial ordinance was established in China by the Emperor Chinnung 2800 years before Christ, in accordance with which the imperial ruler sows the rice himself while the seeds of four other kinds may be sown by the princes of his family. This fact, joined to other considerations, induced Alphonse de Candolle, the Swiss botanist, to consider rice as a native of China. It was very early cultivated in India, in some parts of which, as in tropical Australia, it is indigenous. It is not mentioned in the Bible, but its culture is referred to in the Talmud.

There is no evidence of the existence of rice in Egyptian remains, nor is there any trace of it as a native plant among the Greeks, Romans, or ancient Persians. There is proof of its culture in the Euphrates Valley and in Syria four hundred years before Christ. Crawfurd, the British Orientalist, considers that rice was introduced into Persia from southern India. The Arabs carried the plant into Spain under the name "aruz," the *arros* of the Spanish, the *rizo* of the Italian, whence our word rice. Rice was first cultivated in Italy near Pisa in 1468.

The South Carolina rice is said to be the best produced in size and quality. The introduction of rice into the United States (lower Carolina) dates from the middle or close of the seventeenth century. It occurred through the accident of a vessel being blown out of her course and putting in at Charleston. A small quantity of rice given by the captain to a colonist was used as seed, and this was the beginning of the American rice industry. From the Carolinas and Georgia it has gradually spread to other Southern States, and at the present time the production in Louisiana is very important, and in Texas during recent years it has made great progress.

Rice is one of the principal articles of food in all tropical and subtropical countries, and is one of the most prolific of all crops. It is chiefly a farinaceous food, and requires to be combined with fatty and nitrogenous substances, such as milk or meat gravy, to satisfy the requirements of the system. A large proportion of the rice carried to Europe is used for starch-making, and some is taken by distillers of alcohol. Rice is also the source of a drink in India, and the national beverage of Japan—saké—is prepared entirely from the fermented grain.

THE FRUITS THAT WE EAT

Among the many industries upon which people depend for the supply of food, the cultivation of fruit is one of the most important. It means the planting and caring for fruit until it ripens and so becomes fit for eating. When we think of fruits in their original wild state, and of the labor and skill employed in the different zones of the earth to bring them to the stage of high cultivation, we realize that this form of industry ranks with those that tax the minds and muscles of men in order that the world may enjoy great benefit. In the tropics, however, fruits need but little cultivation, for there they grow spontaneously—that is, naturally. Little or no help of man is required for a good yield of bananas, guava-fruit, oranges, etc., in such favored climes.

But few wild fruits of the larger varieties in temperate climates are really edible, or as we say, "good to eat." We know how sour and harsh are wild grapes and cherries and crab-apples. Think how wonderfully they are changed by cultivation, the crab into the golden pippin, the grape into a Concord cluster! And cultivation must be carefully attended to all the time, if fruits are to be kept up to the standard of excellence. As a rule, the more perfect fruits have come by selection of man, for wild fruits reproduce only themselves. All our perfect apples, pears, plums, grapes we owe to the selection and care of generations of cultivators. The best fruits have a tendency to go back to the wild state. John Lindley, the great botanist, tells us that "if the arts of cultivation were abandoned for only a few years, all the annual varieties of plants in our gardens would disappear and be replaced by a few wild forms." And so too it would be with our choicest fruits at last if we neglected to take care.

Great improvement in the quality of fruits has been made by cross-breeding and by grafting. When, for instance, we read of what has been done by Luther Burbank, of California, we wonder at the ways in which human knowledge, skill, and patient study and labor can improve, for human purposes, upon the handiwork of Nature herself.

Grafting was practised by the ancient Greeks and Romans. It is said that the fruit-growers of France are able to graft in more than fifty different ways. In grafting we take advantage of Nature's teaching, for we find that the spring is the proper season in which to do it, for then the sap stirs and rises, beginning earliest, perhaps, with plum and cherry trees and ending with the pear and the apple. A delicate form of grafting is called budding—the inserting of a bud from one kind of tree into the slit bark of a different kind of tree. This can easily be done with trees that bear stone-fruits, but which are difficult to graft by inserting a scion or shoot.

Fruit-trees, grape-vines, and berry-bushes are propagated also by cuttings—that is, by taking twigs from a good variety and setting them out to take root, or else by suckers and layers. Suckers are shoots sent up from the root that may easily be detached, and properly planted they will usually grow. A layer is a shoot or twig laid in the ground to take root without being detached from the parent plant.

If any of our readers intend to become fruit-growers, they will do well to remember that nothing is more important than well-chosen and thoroughly prepared soil. Dry or barren soil will not produce good fruit, and successful cultivation depends much upon fertilizing, watering, and sifting the orchard or vineyard bed. Growing fruit should be carefully guarded from diseases and from insect pests. With due attention to these and other essential things the fruit-cultivator will find that Nature is ready to reward him with rich returns.

What kind of fruits do you like best? One authority on fruit-culture assures us that the apple is the king of fruits wherever it may be successfully grown. It is found in almost every country

that has a temperate climate. No other fruit succeeds over so wide a range of the earth's surface and under such variations of climate, and none brings so sure a return for time and money spent upon its production. The apple is now no longer a luxury, but a staple article of food. It is the only fruit of the temperate climates that may be obtained and enjoyed in its natural state throughout the year. Modern methods of storage extend its period of usefulness, and quick transportation greatly increases its commercial value.

In its effect upon health the apple has few rivals among cultivated fruits. Its mild and pleasant acid is a remedy for many of our ills. What can be more pleasing to the palate or more beautiful to the eye than the rich, ripe, golden pippin plucked fresh from the tree, or what more toothsome and healthful when cooked? What more delicious than the baked apple served with sugar and cream, or the apple dumpling or pie that the skilful housewife so well knows how to make? What is more firmly fixed in the mature man's memory than the happy days of boyhood when climbing into apple-trees and filling pockets with luscious fruit from bending boughs was one of life's keenest joys?

It is only in quite recent years that apples, in this country, have been grown in very great commercial quantities. Formerly small family orchards of fifty or one hundred trees were the average planting. But now apple-growing has advanced to the front rank of commercial industries. Instead of those small family orchards we now find orchards of hundreds and even thousands of acres in extent, whose products are not only for home markets, but also for large export to foreign countries, both in fresh and cured forms. So vast has the crop become that storehouses and refrigerators, evaporators and establishments for expressing the juice have been built at all points in fruit districts where necessary for handling crops.

In the United States are certain districts especially suitable for the cultivation of apples. Among them are the Ozark region in Missouri and Arkansas, the elevated parts of Virginia and North Carolina, the New England, Middle, and some of the Western States—sections of Colorado, Idaho, Oregon, and Washington. But we are quite safe in saying that there is not a State in the Union in which the apple, in some of its varieties, may not be successfully grown. In 1910 this country produced more than 175,000,000 bushels of this fruit. North America is the greatest apple-growing region of the world. Canada shares with our own country in vast shipments of this product. We export apples to Great Britain, as well as to other European countries, although Great Britain herself grows some of the best apples, besides excellent pears, plums, and grapes. England also imports large quantities of apples from various other countries. In England, as here, cider is made from apples.

For eating in the raw state, as well as for cooking and preserving, many people have a preference for the pear, which is now one of our most valued orchard fruits, although pears are by no means so extensively cultivated as apples or grapes, or peaches. The pear was early introduced into this country from Europe, and the pears that we grow belong mainly to a species of which there are thousands of cultivated varieties.

Pears are grown in many large districts of the temperate zones, but the United States and France produce more than other countries. The Northeastern States, from New England west to the Great Lakes, California, and parts of Oregon and Washington give us the greater part of our annual crop. How handsome the shining rows of fine pears look as we see them in our fruit-stores or on the stands or push-carts of city streets!

But of all our fruits is there any in higher favor than the peach? It has a long history behind it and is welcome in every land to which it may come to-day. Ages ago it went from Persia into Europe, although its first home is supposed to have been China, and from Europe it came to America. In our own country—at any rate in North America—nearly three hundred varieties are now grown. From southern New England to Georgia, on the shores of the Great Lakes, in parts of Illinois, Missouri, Kansas, Texas, and over almost the entire area of California, the peach is successfully grown, Maryland, Delaware, Georgia, and Michigan being the regions most famous for its cultivation. In our land we grow peaches in orchards, as we do apples and pears. In Central Europe and in England peaches are commonly trained against walls or other supports, and cultivated in pots and under glass. The canning of peaches is now a large industry.

If there *is* a fruit to be preferred for beauty and flavor above the peach, it is, perhaps, the strawberry. That old English doctor who "was wont to say that God could have made, but God never did make, a better berry" has had many to agree with him in that opinion. In England it is claimed that some fruits are grown better than in any other country, and that the strawberry, like the gooseberry, is one of them. It is grown there, as also here, during the winter in hothouses, so that the fruit may be ready by the end of February or the beginning of March. Strawberries so produced cannot be bought in England, at the

first marketing of them, for less than a sovereign (nearly $5) a pound. They cost half a crown (61 cents) per pound to grow. The strawberries which everybody eats in England are grown in the open fields, chiefly in Kent. They ripen in June, and the best are all picked in three weeks. Many come from France, but the English people think that they are not quite so nice as their own.

And we, in our country, think that we have strawberries as good as can be grown anywhere. It is true too that our plants are hardy, and from Florida to Alaska there are few districts where the berries may not be grown. Within the past century thousands of varieties have been introduced here, of which those that survive in popularity are a most valuable article of cultivation as well as a most delicious luxury of the table. Still it must be said that most of our varieties are fruitful for only a short season, while some European plants bear throughout the summer and into the fall.

Much as the strawberry has been "improved" by many years of testing and cultivation, yet there are persons who think that the flavor of the wild berry, at its best, is even finer than that of any cultivated variety thus far produced.

There are some countries whose people, if there were no ships and sailors, would never see an orange or a lemon. They want millions of oranges every week, and they have to get them from other lands. Oranges and lemons grow in sunny Spain and Portugal and Italy, but in Italy the trees must have little huts put over them in winter. Some of the nicest oranges grow in Syria, at Jaffa, which in the Bible is called Joppa. California and Florida send an enormous number of oranges to other parts of the United States and to foreign countries.

Orange-trees, we are told, first grew in India. Long ago specimens were brought to America, and in the warm States above mentioned the orange now flourishes abundantly. China also grows the orange, and the tangerine comes from a Chinese orange called the mandarin. The blood-orange comes from Malta.

Lemons need the same sort of climate as oranges, and grow freely in the countries round about the Mediterranean Sea. That was the first home of the lemon, but now it grows also in the East and West Indies, and, like the orange, is being cultivated in California and Florida and in some parts of Australia. Its juice makes a delicious drink, and is valuable to the sailor as medicine.

The pineapple, which is the fruit of the pineapple plant, is very fragrant and palatable, and its juice is much used for flavoring. From a diameter of four or five inches, and a length of eight or ten inches, as we usually see them in our markets, pineapples sometimes reach a far greater size and weigh as much as fifteen or twenty pounds. The pineapple is a native of tropical America, and is widely known in warm climates. For American and European markets the chief regions of production are the West Indies, Bahama Islands, the Azores, and parts of Northern Africa. Australia is supplied by Queensland. In California, Hawaii, and Florida —especially in the latter State—pineapples are to some extent cultivated.

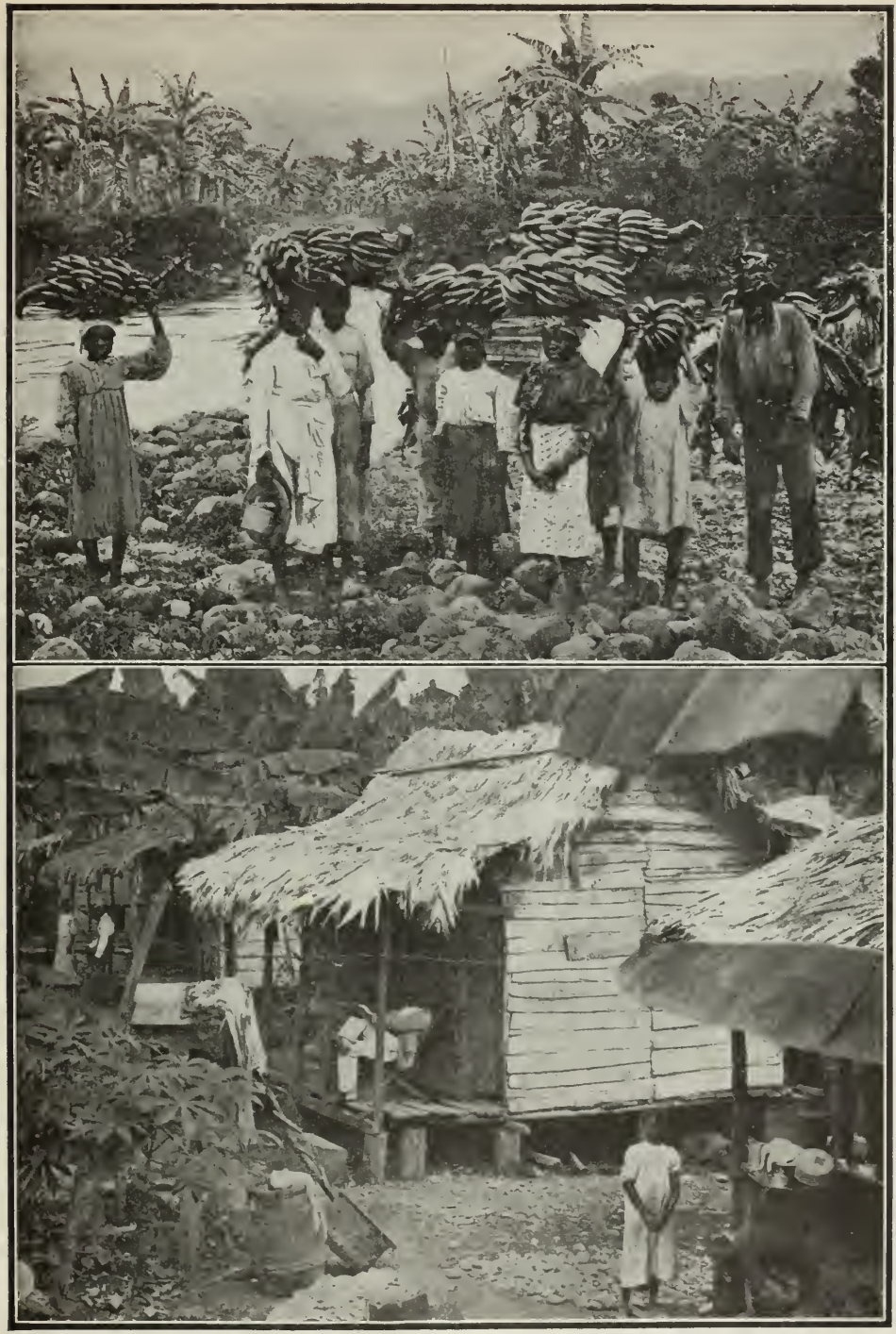
In England pineapples are grown in hothouses, but the soil in which they are rooted must be buried in peat or tan and surrounded by hot-water pipes. There is nothing that an English gardener more dislikes than growing pineapples, as the air of the greenhouse is so hot, and the sharp leaves of the plant cut his hands so badly. It costs a guinea (about $5) for every pineapple grown in England; so only rich people can afford them.

Grapes grow in great variety in this hemisphere, in every European country, in Australia and Africa, and in Asiatic lands—so that we may almost say they grow all over the world. Raisins are grapes which have been dried. They are produced mainly in Spain and Turkey, but also in California and Chile. It is supposed that grapes were first grown in Persia. In France, Germany, Italy, and other countries grapes are grown in the open vineyards. There are no currants better than the best of ours, whether red or white. The dried currants which come from Greece, for cakes and buns, are not like our currants. They are little red grapes, which have been dried. So they really are small raisins. The sultana raisins are seedless grapes from Turkey.

Blackberries are to be found wherever brambles grow. By many they have long been little valued, perhaps because they were abundant and cheap. Even where most plentiful they ought to be well esteemed, for they ripen when all other fruit is gone. The blackberry is hardy, and grows bravely until the frost and snow come.

The raspberry is another type of fruit grown in nearly all lands. It makes excellent tarts and jam, and a vinegar that is very valuable for people suffering from illness. The pity is that the raspberry goes bad almost as soon as it is ripe.

Dates mostly come to us preserved, from Egypt and other parts of Africa; India and China also send them to the West. Some are now grown in parts of the Southern United States. But to us the date is a luxury; to the people in the East it is their food and the principal part of their



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THE NEGRO IN THE ANTILLES AND CENTRAL AMERICA.

UPPER: CARRYING BANANAS TO MARKET, JAMAICA.
LOWER: IN THE CHAGRES RIVER VALLEY, PANAMA.

wealth. A date-tree begins to bear fruit when eight years old. It is at its best when thirty years old, but if properly treated shows no weakness till over one hundred. It is meat and drink in the East. The date is food; so is the bud of the date-palm, which is boiled, like a cabbage, and from the sap of the tree date-honey is made.

Even more important is the fig, which we get from the Mediterranean countries and from India. In India it is food for the poor. Its juice makes a drink and also dyes cloth; its leaves polish ivory; the bark makes cord. The poison of one kind is placed on the tips of spears and arrows with which the natives fight wild animals.

One of the much-prized fruits that we see everywhere that fruits are kept for sale in our cities—the banana—we cannot, unfortunately, grow to much extent successfully, for it is a tropical fruit. We obtain it in great quantities from Cuba and the other West Indies, from Central America, and from southern Mexico. In those regions the cultivation of the banana is a profitable industry, in which not a few settlers from this country are engaged. From some of those countries, and also from the Canary Islands, bananas are shipped to Europe.

Melons like moisture as well as warmth. They are most plentiful in the warm, moist regions of our own country. Many, however, are produced in Spain and Portugal.

Cherries grow in many countries. The German farmers line the edges of their fields with cherry-trees, and the poor peasants use the fruit in soups. We grow cherries here from coast to coast.

THE HOME FRUIT-GARDEN

A FRUIT-GARDEN consists of an assemblage of fruit-bearing trees and shrubs, maintained for the purpose of supplying the family with fruits. In its general purposes, then, the fruit-garden is intended to accomplish results similar to those of the vegetable-garden. In distinction from an orchard, the fruit-garden is less in area, is intended for home rather than market purposes, and therefore has a much greater variety of fruits.

Considering the general liking and desire for fruits by people of all classes, it is amazing that even those who have suitable grounds and facilities for raising them, and who cannot purchase them because of distance from markets, have not made for themselves home fruit-gardens.

With the growth of the commercial fruit interests of the United States, the home fruit-garden has been lost sight of. Not very many years ago the owners of home gardens not only led in the production of fruits, but were our authorities as to how and where to grow them. To-day these gardens, while no less numerous or important, are overshadowed by the orchards where fruit is grown for commercial purposes.

Home gardens are usually considered quite as much a source of pleasure as of profit. Persons who maintain them do so in order to insure a supply of choice fruits to meet the demands of their own tables, and the idea is high quality rather than large quantity or profit. With them fruit-growing becomes a pleasure and a pastime. But the home garden is often the forerunner of commercial development, and even in those localities where climate and soil are unfavorable to such industries in a commercial way the home fruit-garden of the enthusiastic amateur is certain to be found. All the success attained to-day by the fruit interests of the United States has grown out of the persevering efforts of a few men whose names stand high in the horticultural history of the country. The home fruit-gardens of these men served not only as testing stations for determining the fitness of given sorts for new and untried localities, but they were the propagating grounds from which sorts of the highest quality and greatest commercial value originated. The American raspberry industry dates from the day when Nicholas Longworth transplanted the wild "Blackcap" to his Cincinnati garden. Practically, all of the better hybrid grapes which are now cultivated in the Eastern United States sprung from the home fruit-gardens of Rogers and Rickets, and form enduring monuments to their love for and interest in horticulture. Among modern workers the name of none stands out more markedly than that of Luther Burbank, of California, whose garden has, during the last decade, amplified the fruit list, as well as contributed valuable additions to the hardy ornamentals.

The testing of varieties in new localities and the development and spread of new sorts by the amateur is an important work, but the greatest good accomplished by him is to be found in the wholesome influence which he exerts on the community in which he lives. A community is certain to profit in matters of taste as well as financially from the influence of such growers, and it is to them that we owe our appreciation of high quality. A discriminating taste developed in a neighborhood creates a demand which it pays well to gratify, and the amateur who grows fruits for quality will find a ready market in such a section.

Nearly every fruit-producing region of com-

mercial importance owes its development to the influence of some one individual. In West Virginia, for instance, there are two well-marked commercial fruit developments, each of which is easily traced to the work of one man, who started out with the idea of growing fruit for the home supply. Each of these districts has developed into an important commercial fruit region. The famous grape region that borders the interior lakes of central and western New York had its beginnings in small plantations, the earliest of which there is any record at hand being that of Rev. William Bostwick, put out in the early forties. From this fruit-garden as a nucleus, the whole grape area of the region has developed. The immense vine and citrus industries of the Pacific slope have grown out of the early plantings made by the Catholic missionaries, who carried with them trees and vines and spread a desire for fruit. (In the more arid parts of California and the Southwestern States irrigation makes the soil very productive.) It is safe to say that such illustrations would be afforded by every important fruit-growing region of the country. While this phase of the fruit-garden's influence is important and more apparent than any other, it is certainly no more important or far-reaching than its influence upon the variety-list, even of the commercial growers. The watchful care and perseverance of amateur fruit-growers and plant-breeders have transformed our fruit-list from one composed at first almost exclusively of European varieties into a list which is to-day almost completely composed of American sorts.

The people of this country are notably a fruit-loving and fruit-eating people. Notwithstanding this, however, fruit-culture has grown to be classed among the specialties, and few persons who consume fruit are actual growers. The possibilities in fruit-culture upon restricted areas have been very generally overlooked, with the result that many persons who own a city lot, a suburban home, or even a farm, now look upon fruit as a luxury. This can all be changed, and much of the land which is now practically waste and entirely unremunerative can be made to produce fruits in sufficient quantity to give them a regular place upon the family bill of fare and at the same time add greatly to the attractiveness of the table and healthfulness of the diet.

The home production of fruit stimulates an interest in, and a love for, natural objects, which can only be acquired by that familiarity with them which comes through their culture. The cultivation of fruits teaches how to select. A grower is a much more intelligent buyer than one who has not had the advantages of tasting the better dessert sorts as they come from the tree. If every purchaser was a good judge of the different kinds of fruits the demand for fruits of high quality, which is the ambition of every amateur as well as of every professional fruit-grower, would become a reality. But until some means of teaching the differences in the quality of fruits can be devised the general public will continue to buy according to the eye rather than by the palate.

Besides increasing the fruit-supply and cultivating a taste for quality, the maintenance of a fruit-garden brings pleasant and healthful employment, and as one's interest in growing plants increases, this employment, instead of proving a hardship, will become a great source of pleasure. The possession of a tree, which one himself has planted and reared to fruit production, carries an added interest in its product, as well as in the operation by which it was secured. The unfolding of the leaf, the exposure of the blossom-buds, the development of the flowers, and the formation of the fruit are all processes which measure the skill of the cultivator; and when the crowning result of all these natural functions has been attained in a crop of perfect fruit, the man or boy under whose care these results have been achieved will himself have been made happier and better.

NUTS

It may be said that to explain what a nut really is proves rather puzzling. Is it a fruit, or a berry, a seed, or a kernel? The truth seems to be that in popular language the name is given, somewhat at random, to all these varieties of vegetable growth. A botanist, however, would call a hazelnut a true nut, because he regards it as a one-celled fruit, with a hardened covering containing only one seed, and he would limit the name to such fruits. When we examine for ourselves all the products that are called nuts in commerce, it is evident that the name is not and cannot be restricted to what are true nuts botanically.

A little inquiry will also show that a large number of tradesmen deal with certain so-called nuts in their trade. The fruiterer, for example, offers edible (eatable) nuts in filberts, walnuts, chestnuts, Brazil-nuts, cocoanuts, etc. The Italian warehouseman has pistachio and cashew nuts; the grocer has bitter and sweet almonds and nutmegs; and the druggist has nux vomica, cola-nut, Tonka bean, etc. The oil-dealer has his palm-nuts, peanuts, and Bassia-nuts; the tanner his valonia, myrobalans, and nutgalls; the turner his vegetable ivorynuts; and so on, till a long list

A CALIFORNIA IRRIGATION CANAL.

could be made. The products above named illustrate what are called nuts in commerce, and our imports of such nuts are mainly dependent on the two factors of their being favorite articles of food and yielding valuable oils.

The commercial edible nuts are, so far as our taste is concerned, the filbert, walnut, chestnut, peanut, pecan, hazel, almond, cocoanut, and, to some extent, the Brazil-nut.

Some of the hazelnuts we eat are grown in our own country, and some are brought from Spain, and when kiln-dried are called Barcelona nuts. Varieties of the hazelnut are the filberts and the cobnuts. A large proportion of the ripe and dry walnuts that are consumed here are of foreign growth, the largest quantity and the best varieties coming from Southern Europe. Many, however, are produced in California and other parts of our own country. We grow most of our chestnuts, but also import this variety from Portugal, Spain, and France.

The almond, both bitter and sweet, is one of the important edible nuts of commerce, and is widely cultivated in the Mediterranean area. It grows luxuriantly in Spain and Barbary; indeed Spain seems to be the country for all kinds of nuts. The almond is also extensively produced in California. The varieties of almonds known as Jordan (which should really be *jardin*, or garden) and Valencia come from Malaga without shells; the smaller Barbary or Italian sorts and some of the French are imported in the shells.

We have named only a few of the best known nuts, for if we went through all the known edible varieties the list would be too long. There are, of course, other aspects besides the commercial that should be considered in respect to home-grown nuts; for instance, those of the grower and the consumer, and also that of the naturalist. The grower is chiefly interested in growing and harvesting large quantities of good varieties of nuts, and in combating all pests that might injuriously affect his crop. The consumer in turn looks forward to October as "the month of nuts"; yet nuts are really not at their best when they are overripe.

The naturalist can compare varieties and differences in shape and size, and other peculiarities; but, above all, he can observe the ways of nut-eaters, who carry their crackers in their heads, and hunt for nuts still growing on trees—especially the squirrels!

WHERE THE SUGAR COMES FROM

The history of civilization might be written round the sugar-bowl. We could hardly live without sugar, so important is it to us as a food and a luxury; yet not so very long ago sugar was scarcely ever seen in the homes of the poor. But the sugar-growing industry has become one of the most important in the world, and to-day, though sugar sells for only one-quarter the price that it did in the middle of the last century, a greater quantity is grown than ever was known before.

Sugar is to be found in the sap of many trees, especially in that of the maple. It is to be found in all fruits, and in the nectar of thousands of flowers, but it is from the sugar-cane and from the beet-root that we get our supplies for commerce.

For ages and ages the sugar-cane was the only source of supply, and it is wonderful to think that at one time all the sugar came from a single spot in the world. It would not be safe to say that it was in Bengal that the sugar-cane first grew, but it seems certain that in Bengal the process of extracting the sugar from the cane was first learned by man. Nearly eight hundred years before the birth of Christ the Chinese copied the valuable art from the people of Bengal, and a thousand years later the Persians began to cultivate the sugar-cane. It was the Persian doctors who first introduced the use of sugar into medicine—a fact for which all young patients will bless them. The Arabs, when they established colonies round about the Mediterranean, grew the cane there, and then the cane slowly made its way into Egypt.

Little by little it was carried to other warm countries of the world. Missionaries took it with them, and taught natives to cultivate it; travelers carried it to the lands which they explored; and eventually sugar-cane was grown throughout the West Indies, the East Indies, the warm lands of the southern United States, in many South American countries, and elsewhere.

It was the discovery of the richness of the beet-root in sugar that sounded the death-knell of the sugar-cane. Beet is grown in enormous quantities in Europe. Russia, Germany, and Austria have built up a vast trade in beet-sugar. In our own country too the beet-growing industry is important.

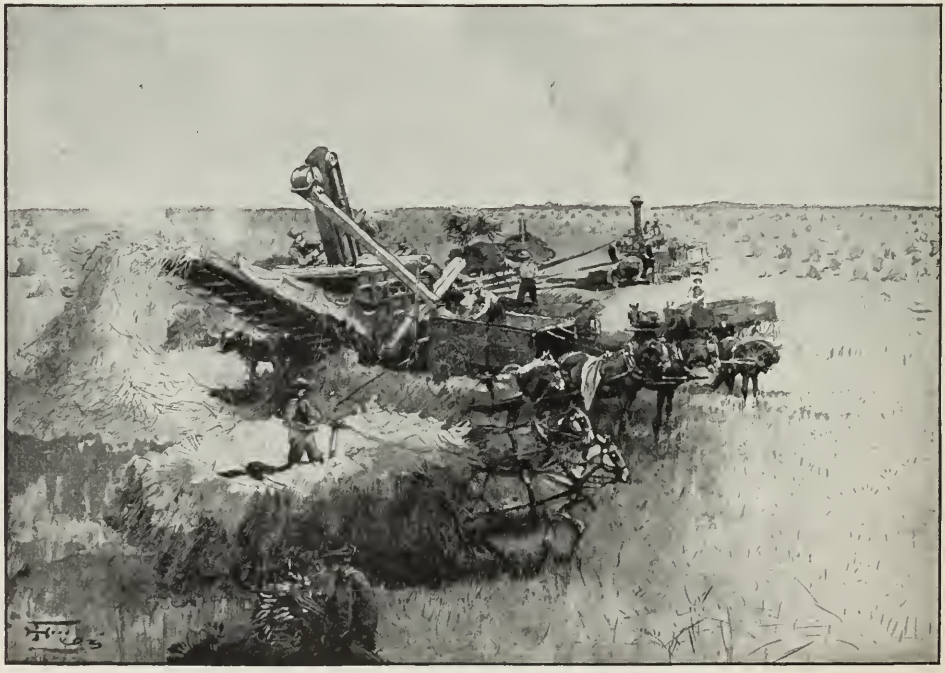
A FAMOUS HORTICULTURIST

The most remarkable achievements in connection with plant-life ever known to be due to the work of an individual are those that have given world-wide fame to an American farmer's son living (since 1875) in California—Luther Burbank, born in Lancaster, Massachusetts, in 1849.

Although he has been described as a "modest gardener," his successes as an originator of new varieties of plants, fruits, and flowers have placed him in the front rank of naturalists. While still a very young man he originated the Burbank potato, and on his experiment grounds near Santa Rosa, California, he has developed new varieties of plums, prunes, etc., apples, peaches, nuts, berries, roses and other flowers, grasses, grains, and trees. He has also produced a thornless cactus that furnishes food for man and beast. No other cross-breeder of plants has ever approached him in scientific and practical results. His new varieties are numbered by thousands. A fine example of his great results is shown in the hybridizing of the black walnut and the English walnut, whereby he produced a new species with fruit very much larger and more valuable than the fruit of either parent, and a more rapid-growing tree. Of the thousands of new plums that he has produced, many are superior to the parent varieties. In fact, according to the great naturalist Hugo de Vries of Holland, "the magnitude of Burbank's work exceeds anything that ever was done before, even by large firms, in the course of generations. Others confine themselves to one or two genera; he takes hold of everything." How rich an experience must it be to have such intimacy with nature!

Few more wonderful stories have ever been told of man's mastery of the secrets of nature than that of Luther Burbank's conquests in the field of plant-breeding. "Upon no species of plant life," says a student of his methods, "be it flower, berry, or fruit, has crossing and hybridizing failed to produce the most wonderful changes. When a change is noted the avenue is opened for variations in every direction."

As to the practical possibilities of these operations, the testimony of Luther Burbank himself is astonishing: "It would not be difficult," he declares, "for one man to breed a new rye, wheat, barley, oats or rice that would produce one grain more to each head; or a corn to produce an extra kernel to each ear; another potato to each plant; or an apple, plum, orange, or nut to each tree. What would be the result? Nature would produce annually, without extra cost or effort, 5,200,000 extra bushels of corn, 15,000,000 extra bushels of wheat, 20,000,000 extra bushels of oats, 1,500,000 bushels more of barley, and 21,000,000 extra bushels of potatoes. Not for one year only, but as a permanent legacy for all future generations!"



A THRESHER AT WORK.

ANIMAL FRIENDSHIPS AND PHOTOGRAPHS

REARING A WREN FAMILY

BY WILLIAM LOVELL FINLEY

Illustrated with photographs from life by Herman T. Bohlman

"WHY *should n't* a little wren have an enormous appetite?" I mused as I lay hidden in the tall grass watching the father as he fed the eldest of the family of five, that had flown for the first time from the nest in the hollow stump to the alder branches below. "Of course we must admit that the diminutive bobtailed youngster must possess the most rapid double-action digestive apparatus when we remember that he grows to maturity within two weeks from the day he was hatched. Therefore the chief object of his life must be to eat and sleep."

Wrens are interesting little chaps anyhow—droll, fidgety little individuals, each with great self-esteem. My interest in a certain brown family had increased with every visit for a whole month. One picks up many acquaintances rambling about the hills, but, like people, some are more interesting than others, and acquaintanceship often warms into friendship as the days pass by.

While out birding in the latter part of June, I was trudging along up one of the shaded paths of the fir-covered Oregon hillsides, when a little bird whizzed headlong down in its tippling flight, barely dodging my head. Both were rather flustered at this sudden and unexpected meeting. The moment's pause on an overhanging branch was sufficient for me to recognize the hurrying stranger as a Vigors's wren. But I hardly had time to see just what the small white parcel was she carried in her mouth. It might have been a white miller, which I imagined would soon be thrust unceremoniously down a gaping throat. For all my strategy, this little brown bird was too shrewd to show me her home.

The next day, however, I stole a march, and was well hidden in the bushes near to where I thought the nest must be, when the wren appeared. I hardly expected to escape that sharp round eye, and was prepared for the scolding that followed; in fact, I submitted rather joyously to it, without a word in reply. Perhaps I had no business there on the wren's busiest day. Regardless of all the harsh epithets hurled at me from the alder limb, I was too absorbed in gazing through my field-glass at an ugly piece of snake-skin the wren held in her mouth. Rather an uncanny mouthful, to be sure. The idea of a nestful of gaping mouths vanished from my vision as the brown body fidgeted about, with her tail over her back, and then whirled away to a large upturned root covered with vines. Here she hopped about in the tangle of brier and fern, apparently forgetful of my presence; but those sharp brown eyes, behind which are generations of care and cunning gained in contact with nature, are never heedless. Her action would have deceived any other creature, but I knew her too well; at the likeliest moment and in an eye's twinkling, she suddenly popped up into the dead body of an alder-tree and disappeared into a tiny round hole.

Wrens have traditions, and, like some people, are perhaps slightly superstitious. I was not sure that a Vigors's wren considered a bit of snake-skin the keystone to the arch of its snugly built home, but I do not remember ever examining the nest of its cousin, the Parkman's wren, and not finding this traditional bit of treasure. Maybe it is a matter of protection, for it is said a snake will not venture where the vestige of its own skin is found. Generations ago the ancestral wrens must have fought for protection among the tribes of reptiles, until now the descendants never

"CATCHING IN THE BRANCHES BELOW WHERE THE FATHER PERCHED."

think of starting upon household duties without searching up the hillsides, through the meadows, or back in the deep woods until the cast-off scaly coat of some snake is found and borne home in triumph as a hearthstone deity.

Almost every feathered creature has some interesting trait of protection. I have always found that the red-breasted nuthatch, after he has excavated his wooden home in some dead stump, never fails to collect a good supply of soft pitch, and plaster it religiously about the circled doorway of the log house.

Ever since I first discovered the wren building its home in the alder stub my interest had grown, and I was anxious to win its friendship, principally because most birds had finished nesting for the season. Why had the nest not been placed nearer the ground instead of at a distance of twelve feet, and why did they select such a dark, narrow home that I could hardly get a glimpse of the interior?

Experience had taught me not to try to win the affections of a bird too rapidly, especially at that season when household affairs were so engrossing. When I thought I could safely do so, I approached the nest rather cautiously and timidly and sat down in the tall ferns. It surprised me somewhat that neither parent scolded at my approach. After watching and waiting for almost half an hour and seeing neither wren, I became impatient and knocked gently on the tree-trunk to pay my respects to the brown head that might be thrust from the round door above. Again I knocked, and then a little harder. It 's queer a wren cannot feel such an earthquake against the pillar of her home. I shook the tree vigorously. Could it be possible the home was deserted? Visions of all sorts of bird accidents flashed through my mind as I swung up into the branches

"HIS FEATHERS RUFFLED UP IN ANGER AND AN ASTONISHED *PEEP* OF DISGUST ESCAPED HIS THROAT."

"IN A FLASH BOTH WRENLETS WERE WIDE AWAKE AND ON THE TIPTOE OF EXPECTANCY."

and rapped at the round door. All was dark within; not even the white eggs could be seen. This was bad luck indeed, I thought. Then, with the aid of a little mirror that is always handy to examine dark crevices, I reflected a ray of light through the door to the innermost depths. There sat the mother, her brown back almost indistinguishable from the dry sides of the house, but those round dark eyes gleamed out from the gloom. Nor did she have any idea of deserting her post for all the shaking and knocking without.

When I visited the little wooden home the first week in July there was a decided turn in the tide of wren affairs. The news was heralded from the tree-tops. The energy that was used in keeping the secret of the little home a week previous was doubled in the eagerness to spread it among feathered neighbors far and wide. For two long weeks the mother and father had covered and caressed their five eggs of speckled white, until they suddenly teemed with inward life and five tiny bodies burst forth from the prison walls.

The father wren—it is often the case—was rather timid while we were around. He had a particular fear and dislike for the great three-legged, one-eyed creature—my camera—that was hidden dragon-like so near his home. Birds have many enemies, and a nest is seldom left without its guard. We soon discovered that this was the father's duty. His harsh, scolding note, sounded from the surrounding boughs, always reminded us that we were trespassing.

It was the mother's duty to forage. Returning from the hunt with food, she whisked about with a "what-are-you-doing-here" look of inquiry. Although flustered somewhat at first by our presence, she soon came to regard us with an air of indifference. A moment's pause on her threshold, and into the round opening she would pop; then, as if amazed at the increasing appetites she had to appease, she would dart out and away for a new supply.

About the hillside and down along the little stream the mother searched continually the entire day for grubs. Each time returning, she would pause on the top of one of the trees near by and pipe her merry little trill. This note of home-coming the father never failed to hear, and it

was he that always gave the response of "all 's well." I was amused to hear how readily the wrenlets learned to recognize the voice of their mother. Her song of arrival soon came to be answered by such a chorus of tiny cries from the round door that she could not resist hurrying headlong to the nest. Several times, from my "rabbit's hole" in the bushes, I saw a song-sparrow stop on swaying limb and sing a song somewhat resembling that of the wren, but the children in the wooden home knew not the song, and, true to their parents' teachings, remained quiet while the doughty father darted out and drove the intruder from the premises.

On July 23 I wrote in my note-book: "This morning I was surprised to see two little brown heads as I gazed through my field-glass at the round nest-hole." But how could I ever get pic-

"MERCY! SUCH A REACHING AND STRETCHING!"

tures of the wren nestlings if they were to remain continually within those protected wooden walls?

For some reason the father stormed and scolded more than usual on my next visit. He seemed out of sorts about everything. The rating I got was not very much more severe than the little wretch gave his wife when she returned each time with morsels of food. Something was radically wrong. It could not be that his mate did not search hard enough for food or bring enough back. With all his fault-finding, he never once offered to relieve his faithful wife.

Hidden in the grass, I tried to solve the secret of the father's petulant actions. Each time the patient mother returned he grew more restless and violent in his language. Soon I saw his wife whirl joyously by with an unusually large white grub—surely a prize for any bird. But alas! for all her prowess, her spouse darted at her as if in madness, while she, trembling in terror, retreated down the limb and through the bushes. For a few moments it seemed as if the wren household was to be wrecked. I was tempted to take the mother's part against such cruel treatment as she quivered through the fern on flutter-

ing wing toward me, but at that moment, as if thoroughly subdued, she yielded up the bug to the father. This was the bone of contention. A domestic battle had been fought and he had won. The scolding ceased. Both seemed satisfied. Mounting to the tree-top, the little mother poured forth such a flood of sweet song as rarely strikes human ear. From that moment she seemed a different wren, released from all care and worry. Her entire time was spent in search for bugs. Each return was heralded by the high-sounding trill from the tree-top, and her husband whirled out of the tangled vines to take the morsel she carried.

But what of his actions? He had either gone crazy or he was a most selfish little tyrant, for he flew about the alder stump, calling now in a softer tone to his children within, and finally swallowed the grub himself. Two or three times he did this, until I was so disgusted I could hardly endure him. If he were hungry, why could he not skirmish for his own bugs?

While I was chiding him for his infamous action, the mother appeared with a large moth, which he readily took. Among the alder limbs the father flew, and finally up to the nest-hole, out of which was issuing such a series of hungry screams as no parent with the least bit of devotion could resist. Hardly could I believe my eyes, for the little knave just went to the door, where each hungry nestling could get a good view of the morsel, then, as if scolding the little ones for being so noisy and hungry, he hopped back down the tree into the bushes.

This was indeed cause for a family revolt. The brown nestling nearest the door grew so bold with hunger that he forgot his fear and plunged headlong down, catching in the branches below where the father perched. And the precocious youngster got the large moth as a reward for his bravery.

Not till then did it dawn upon me that there was a reason for the father's queer actions. The wrenlets were old enough to leave the nest. Outside in the warm sunshine they could be fed more easily and would grow more rapidly, and they could be taught the ways of woodcraft. In half an hour, one after another, the little wrens had been persuaded, even compelled, to leave the narrow confines of the nest and launch out into the big world.

What a task the father had brought upon himself! Surely the old woman in the shoe never had a more trying time. The fretful father darted away to punish one of the wrenlets for not remaining quiet; he scurried here to scold another for wandering too far, or whirled away to whip a third for not keeping low in the underbrush, away from the hawk's watchful eyes.

My attention was directed in particular to one little feathered subject who, each time the brown father came back, insisted vociferously that his turn was next. Once in particular, when the camera did not fail to record, papa wren was approaching with a large grub. The wrenlet was all in ecstasy. He was calling, "Papa, papa, the bug is mine! The bug is mine!" fluttering his wings in such delight as he hopped to the next limb near the hesitating parent. But the youngster's emphatic appeal failed to persuade the father, for the next instant he deposited the morsel in the mouth of the less boisterous child. What a change in my enthusiastic little friend, who at one moment fairly tasted the dainty delicacy and the next saw it disappear down the throat of a less noisy brother. He stood looking in amazement, as his feathers ruffled up in anger and an astonished *peep* of disgust escaped his throat.

Another day in the warm sunshine and the wrenlets began to act more like their parents and to gain rapidly in worldly knowledge. The third morning all was quiet and I thought the family had departed for other hunting-grounds. Soon, however, the father appeared, and then the mother, scolding as usual. I crawled down under the tall ferns to wait. The parents had taught their children the act of keeping quiet very well, for not a peep was heard. But those ever-growing appetites soon mastered caution, and, regardless of the continual warnings, there was a soft little *wink! wink!* in the direction of the vine-covered stump. 'T was hardly an exclamation of delight, but just a gentle reminder lest the busy parents forget. Gradually these little notes of admonition increased in number and volume till the full chorus of five impatient voices arose from among the tangle of vines and ferns.

My continued visits had made fast friends of the little fellows. Two of them took their position on the top of a little stub where the father was accustomed to light. Here they sat in sleepy attitude, each awaiting his turn to be fed. Not the least accommodating were they, from the photographer's point of view, for generally when the camera was focussed for the picture they would nod lower and lower, as children do at bedtime, till both were sound asleep in the warm sunshine. It was remarkable, however, to witness the effect of the mother's trill as she heralded the approach of something edible. In a flash both wrenlets on the wooden watch-tower were wide awake and on the tiptoe of expectancy.

Often do I remember trying to play foster-

parent to young birds, and yet, with all my care and patience, I seldom succeeded. A week before, when I held a large spider temptingly near the nestlings, they had crouched back in terror; but by this time they had certainly gained in worldly wisdom. I, indeed, had not been watching the wrens for the past two weeks without learning. I had seen the mother hop up and down an old stump, like a dog after a squirrel, till she would soon haul out a big grub.

Digging into this bird-storehouse with my knife, in a trice I collected half a dozen fine fat worms—a stock of provisions that would take the mother two hours to gather. Why are young birds so particular, anyhow? What difference does it make whether their dinner comes from the mother's mouth or from some kindly disposed neighbor?

"I 'll just test the little wrens once more," I said to myself, as I impaled two of the choicest grubs on a sharpened stick. It was impossible for me to announce the approach of this delicious dinner with the soft little *wink! wink!* of the mother, but I patted both the sleepy birdies on the back and, rather hesitatingly, held up my offering. There was hardly room to doubt its acceptance. Mercy! such a reaching and stretching! I could not divide up fast enough. Nor was one grub apiece sufficient. Quiet was not restored till each wrenlet had stored away two of the largest and fattest.

For the first time the parent wrens seemed to realize that I was actually of some use. The trying task of satisfying five growing appetites was lessened to some degree, and the busy parents took household affairs somewhat more easily the rest of the day.

The next time I saw the wren family, all the young were scampering about in the bushes, following their parents hither and thither, earning their own livelihood and rapidly learning for themselves the arts of woodcraft.

WARBLER WAYS

BY WILLIAM LOVELL FINLEY

With photographs by Herman T. Bohlman

DURING the warm days of June, when the mystery of life seems suddenly unveiled in a miraculous manner, I often frequent a woody retreat above the old mill-dam on Fulton Creek. The water gurgles among the gray rocks and glides past a clump of firs and maples. Star-flowers gleam from the darker places of shade, white anemones are scattered in the green of the grass-blades and ferns, and Linnean bells overhang the moss-covered logs.

As one sits here in the midst of the woods the chords of every sense are stretched. His eye catches the cautious movements of furry and feathered creatures. His heart vibrates with the rhythmic throbbing of the forest pulse.

One day, as I lay idling in this favorite haunt, a shadow caught in the net of sunbeams spread under the maple. A black-throated gray warbler fidgeted on the limb above with a straw in her bill. This was pleasing. I had searched the locality for years, trying to find the home of this shy bird, and here was a conclusive piece of evidence thrust squarely in my face.

The site of the nest was twelve feet from the ground, in the top of a sapling. A week and a half later, I parted the branches and found a cup of grasses, feather-lined; nestled in the fork of the fir. There lay four eggs of a pinkish tinge, touched with dots of brown.

The chief source of satisfaction in a camera study of bird life comes not in the odd-time chances of observation, but in a continued period of leisure, when one may spend his entire time about bird homes just as he takes a week's vacation at the seashore. To be a successful amateur bird-photographer one has fairly to make a business of lying in wait for his subjects hour after hour, day by day, and maybe week after week.

The real value of photography is that it records the truth. The person who photographs birds successfully has to study his subjects long and carefully. He is not likely, therefore, to get only a scanty set of notes and be compelled to complete his observations when he is seated in the comfortable chair of his study. For this reason, a camera in the hands of some of the recent nature-writers would be of great value to science, if they could picture some of the humanized habits of creatures they have described with the pen. Of course, in the study of art, we may try to improve on nature, but in nature-study truth is the important element. We might as well understand that a beast or bird is interesting because of its own wild individuality, not because it is a man dressed in fur or feathers.

Of course it showed a pure lack of discretion to try to picture the home of such a shy warbler during the days of incubation, but I half believe the feathered owners would have overlooked this, had it not been for the pair of blue jays that bucaneered that patch of fir. While we were getting a picture I saw them eying us curiously; but they slunk away among the dark firs, squawking jay-talk about something I did n't understand. Two days later we skirted the clump to see if the sense of warbler propriety had been too severely shocked by the camera. In an instant I translated every syllable of what that pair of blue pirates had squawked. The scattered remnants of the nest and the broken bits of shell told all.

"A CUP OF GRASSES, FEATHER-LINED, NESTLED IN THE FORK OF THE FIR."

These gray warblers, however much they were upset by the camera-fiend and blue-jay depredations, were not to be thwarted. They actually went to housekeeping again within forty yards of the old home site. The new nest was placed in a fir sapling very like the first, but better hidden from marauding blue jays. It was supremely better located from the photographer's point of view. Just at the side of the new site was the sawed-off stump of an old fir, upon which we climbed and aimed the camera straight into the

"THERE, INSTEAD OF FOUR, WERE ONLY TWO SMALL NESTLINGS."

nest. There, instead of four, were only two small nestlings. They stretched their skinny necks and opened wide their yellow-lined mouths in an attitude of unmistakable hunger.

The moment the mother returned and found us so dangerously near her brood, she was scared almost out of her senses. She fell from the top of the tree in a fluttering fit. She caught, quivering, on the limb a foot from my hand. Involuntarily, I reached to help her. Poor thing! She could n't hold on, but slipped through the branches and clutched my shoe. I never saw such an exaggerated case of the chills, or heard such a pitiful, high-pitched note of pain. I stooped to see what ailed her. What! both wings broken and unable to hold with her claws! She fell like an autumn leaf to the ground. I leaped down, but she had limped under a bush and suddenly got well. Of course I knew she was tricking me.

The next day my heart was hardened against all her alluring wiles and "crocodile" tears. She played her best, but the minute she failed to win I got a furious berating. It was no begging-note now. She perched over my head and called me every name in the warbler vocabulary. Then she saw we were actually shoving that cyclopean monster right at her children. "Fly! fly for your lives!" she screamed in desperation. Both the scanty-feathered, bobtailed youngsters jumped blindly out of the nest into the bushes below. The mother outdid all previous performances. She

simply doubled and twisted in agonized death-spasms. But, not to be fooled, I kept an eye on

"I'VE OFTEN SEEN DISPUTES ARISE WHILE THE MOTHER WAS AWAY."

one nestling and soon replaced him in the nest where he belonged. Nature always hides such creatures from me by the simple wave of her wand. I 've seen a flock of half a dozen grouse flutter up into a fir and disappear, to my eyes, as mysteriously as fog in the sunshine.

This fidgety bit of featherhood is called the "black-throated gray warbler," but it is only the male that has a black throat. He is not the whole species. His wife wears a white cravat, and she, to my thinking, is a deal more important in warbler affairs. Mr. Warbler seemed unavoidably detained away from home on matters of business or social importance the greater part of the day, when the children were crying for food.

The first day we really met the gentleman face to face we were trying to get a photograph of the mother as she came home to feed. She had gotten quite used to the camera. We had it leveled point-blank at the nest, only a yard distant. A gray figure came flitting over the tree-top and planted himself on the limb right beside his home. He carried a green cut-worm in his mouth. No sooner had he squatted on his accustomed perch than he caught sight of the cyclops camera. With an astonished chirp he dropped his worm, turned a back somersault, and all I saw was a meteor streak of gray curving up over the pointed firs. I doubt if he lit or felt any degree of safety till he reached the opposite bank of the river.

We met his lordship again the following day. The mother was doing her best to lure us from the nest by her deceiving antics. Every visit we had made she kept practising the same old trick. Just as she was putting on a few extra agonizing touches, I suddenly saw a glint of gray shoot through the air. The father pounced down and drew the feigning mother away.

I could not tell one nestling from the other. As I sat watching the mother the question often arose in my mind: Does she recognize one child from another? Does she feed them in turn, or does she poke the food down the first open mouth she sees? Here is a good chance to experiment, I thought. So with a good supply of 5 by 7 plates

"THE MOTHER FED THE NEAREST NESTLING."

"FOR ALL HIS BEGGING THE NEAREST GOT A KNOCK."

"THE GRAY MOTHER REWARDED HIM WITH A MOUTHFUL THAT FAIRLY MADE HIS EYES BULGE."

"ON HER RETURN, SHE DID NOT FORGET THE HUNGRY FLEDGLING STILL IN THE NEST."

we watched and photographed from early in the morning till late in the afternoon for three days. At the end of that time we had eight pictures, or rather four pairs, each of which was taken in the same order as the mother fed her young.

The warblers foraged the firs for insects of all sizes and colors. The digestive organs of those bobtailed bantlings seemed equal to almost any insect I had ever seen.

In the days we spent about the nest I never saw the time when both the bairns were not in a starving mood, regardless of the amount of dinner they had just swallowed. The flutter of wings touched the button that seemed automatically to open their mouths. At the slightest sound I 've often seen disputes arise while the mother was away. "I 'll take the next!" said one. "I guess you 'll not!" screamed the other. The mother paid no more attention to their quarrels and entreaties than to the ceaseless gurgle of the water. How could she? I don't believe she ever caught sight of her children when their mouths were not open. The fact that the mother fed them impartially appealed in no way to their sense of justice. The one that got the meal quivered his wings in ecstasy, while the other always protested at the top of his voice.

The first pair of pictures in the series was taken while the young were still in the nest. The mother fed the nearest nestling. Changing the plate and adjusting the camera again, we had to wait only three minutes. The bairn at the edge of the nest surely had the advantage of position. But what was position? For all his begging the nearest got a knock on the ear that sent him bawling, while his brother gulped down a fat spider.

"FIRST THE RIGHT RECEIVED A TOOTHSOME MORSEL."

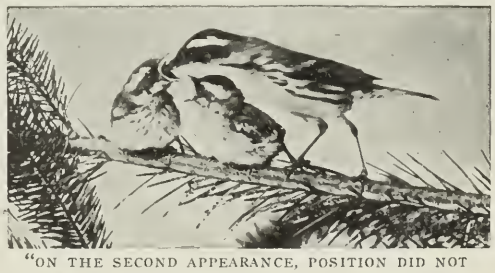
"SOON AFTER THE HUNGRY BAIRN ON THE LEFT GOT A JUICY BITE."

Soon after one of the bantlings hopped out on the limb, and the gray mother rewarded him with a mouthful that fairly made his eyes bulge. On her return, she did not forget the hungry, more timid fledgling still in the nest.

Again we tried the same experiment of having the mother light between her clamoring children. First the right received a toothsome morsel, notwithstanding the impatient exclamations of the chick on the left. Soon after the hungry bairn on the left got a juicy bite, in spite of the vociferous appeals from the right.

"This way we 'll surely baffle the ingenuity of the mother," I thought, as I perched both bantlings on a small limb where they could be fed only from the right. This looked good to the first little chick, for he seemed to reason that

"THIS LOOKED GOOD TO THE FIRST LITTLE CHICK."



"ON THE SECOND APPEARANCE, POSITION DID NOT COUNT FOR MUCH: IT WAS HIS BROTHER'S TURN."

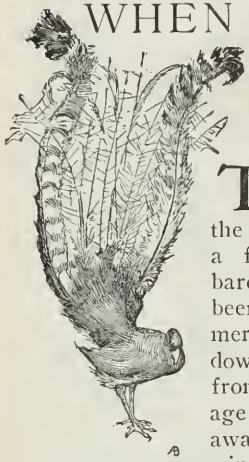
when he opened his mouth wide his mother could not resist his pleadings. He reasoned rightly the first time. On the second appearance of his mother, position did not count for much: it was his brother's turn.

Later in the day I watched the gray warbler coax her two children from the high branches of the fir into the thick, protecting bushes below, for now they must learn to forage for themselves. With the keen sense of bird motherhood she led them on, and they followed out into the broad, wide world of bird experience.

WHEN THE BIRDS WERE OUR GUESTS

(A True Story of My Childhood)

BY F. E. HAWSON

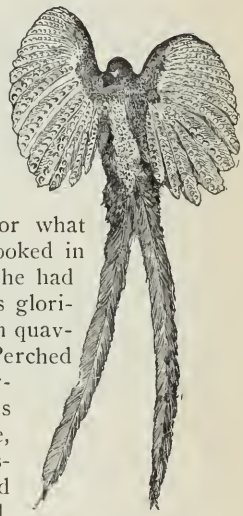


THAT was a dry year in Australia. All through the winter months, except for a few light showers which barely laid the dust, there had been no rain, and when summer came, the fierce sun blazed down upon a bare red earth from which the parched herbage had long since been swept away by the strong north wind, leaving nothing but the dry stumps of the tufted grass. The sheep died in hundreds, and the cattle found scant nourishment by feeding upon the acrid leaves of the bush shrubs.

In the middle of January a day came which was the climax of that awful summer. After a stifling, breathless night, the sun rose like a great red ball, growing hotter and fiercer as he ascended in the heavens, until at noon the air scorched the flesh like the blast from a furnace. Even the leaves of the hardy gum-trees rustled and crackled and withered with the intense heat, while the sandalwood-trees, the wattle and cassia bushes, with each smaller tree and shrub, drooped, their leaves hanging limp and lifeless.

The wild birds, open-mouthed and gasping, met in the giant gum-tree, which in former years had afforded them grateful shade; but now it gave no shelter, for its leaves stood on edge and the burning sun-rays filtered through. Even the eagle-hawk was subdued. With parted beak and outspread wings, he balanced his body on a stout bough and glanced uncaring at his feathered prey, for well he knew the hot blood of birds would not ease this raging thirst.

Following the eagle-hawk's eye, the crow looked down with a sinister smile upon the birds panting on every branch. All were there: Laughing Jack in his brown coat, his boisterous merriment stilled. The magpie, his black-and-white dress, usually so spick and span, now dingy and ruffled, for what bird could care how he looked in such weather? At dawn he had tried a note or two of his glorious morning song, but soon quavered off into silence. Perched on a twig in his pretty garment of soft, eucalyptus green, was little Silvereye, the daring bird who persistently refused to be scared away when a gun was fired, but kept his place in the branches, trusting to his coat concealing him among the leaves which he resembled so closely; instead, he would turn a merry, silver-rimmed eye toward the hunter as though inviting another shot.

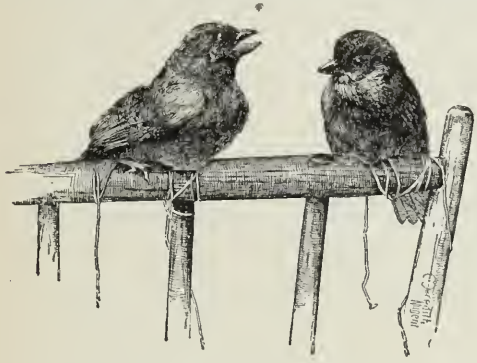


Seated near their brown cousins of the plains were the pretty blue wrens, their lovely dress, brilliant azure on the male, more somber on the female, making a bright spot of color. The "cooloody," a smaller and less aggressive copy of Laughing Jack, was perched beside the dull-coated but musical thrush. The black-and-white flycatcher was there, the friend of the cows, on whose backs he often perches when hunting for his food and their torment, the flies. The whole parrot family was represented, from the great red-and-yellow-crested cockatoos, the screaming pink-and-gray galas, the large, gorgeously plumaged parrots, down to the tiny soft green parrakeets. Besides these there were the ground lark and his silver-voiced brother of the sky, the bronze-wing pigeon, and many other birds of the bush too numerous to mention severally.

All the birds were suffering terribly from thirst, and there seemed no hope of any alleviation of their agony unless rain should come. All the water-holes were dried up. Even the supply of water in the wells appeared to be getting low, and the day before my father had ordered the troughs where the animals watered to be covered, to prevent evaporation, and to keep the dingos from drinking there. He hoped that this frightful weather, if it did no other good, would kill off these enemies of the sheep. Previous to the covering of the troughs, the birds had been accustomed to drink and bathe there in the early morning and in the evening.

For me and my brothers and sisters this terrible day had been a trying one also. We were not allowed to go out of doors for fear of sunstroke, and, restless and tortured by the heat, we had wandered from room to room, unable to lie still as we were bidden, and with no heart for our usual indoor amusements. The only thing which made us forget our discomfort for even one moment was the sight of our friends the wild birds collected in the big gum-tree in front of the house. We knew that their sufferings were greater than our own, and we grieved that we could not help them.

About four o'clock we were all together at the window, looking out, when we noticed a commotion among the dispirited and gasping birds. They seemed simultaneously to have agreed upon



"WHEN THEIR THIRST WAS QUENCHED THEY PERCHED IN VARIOUS ATTITUDES ABOUT THE ROOM."

some plan, for they all dropped to the ground, and slowly, with outspread wings and open mouths, painfully crossed the hot earth between the tree and the house, and presently we saw the marvelous sight of the whole troop, headed by little Silvereye, trailing up to the veranda. In amazement and delight, we called to our mother:

"Oh, mama, mama! The birds—the birds!"

"Open wide the windows," she instantly ordered; "perhaps they will come in. See, children, the poor things are perishing with thirst!"

We obeyed at once, and the birds came panting in, their wings drooping, their beaks apart. Oh, the wonder and the joy of it! Our hearts swelled and almost burst with delight at the thought that the birds—our dear wild birds whom we loved so much—of their own accord had come to us for aid in their extremity.

"THE BIRDS DID NOT MOVE AWAY, BUT ALLOWED US TO TOUCH THEM."

The heat was forgotten in the great happiness of ministering to the needs of our guests. We ran to the kitchen for all the shallow dishes we could find. These we filled with water and placed on the parlor floor. The birds were not slow to understand. They crowded around the pans, and drank and drank, dipping in their beaks again and again, and lifting their heads to allow the cool fluid to trickle refreshingly down their parched throats. When their thirst was quenched they made no attempt to get out, but perched in various attitudes about the room.

The crow flew to the mantelpiece, stood on the corner of the shelf, uttered a weak *caw,* and looked around with an air of great dignity. The eagle-hawk perched upon the arm of the sofa, while the magpie chose a shelf in the corner as a resting-place. Most of the small birds found perches on the fresh boughs father had cut in the early morning, and which mama had arranged in the big open fireplace so as to give the room an appearance of coolness. Laughing Jack looked comical seated silently and gravely on the back of a chair. The prettiest picture was made by a number of parrakeets who sat in a row on the fender. The pigeons, larks, and most of the ground birds crept under the furniture, remained on the floor, or perched on the rungs of chairs.

For a long time we children could do little but gaze in rapture at the birds. That our wild feathered friends should have come to visit us seemed like a bit out of fairyland, and every few minutes we would rub our eyes and look again to see if it were really true.

If we went near, the birds did not move away,

but allowed us to touch them, and Silvereye even hopped on to Arthur's finger and sat there contentedly for quite a while. It was a rare pleasure to take a little unresisting parrakeet, honeybird, crested dove, or blue wren in our hands, hold it up to our ears and listen to the quick beating of the tiny heart, or stroke the soft feathers with our smooth cheeks. But mama said we must not handle the tender creatures much, lest we make them ill. So we satisfied ourselves by watching them, and by going every few minutes to bring fresh water, also bread, which we crumbled on the floor, hoping that our guests might be tempted to eat. But the birds did not care for food. Water and shade were all they craved.

All too short was that happy afternoon. The night closed in hot and stifling, and the birds made no move to go. We were allowed to stay up later than usual, but at ten o'clock were sent to bed. After tossing restlessly for an hour or more, I sank into a troubled sleep, from which I was awakened by flashes of distant lightning and the rumbling of a coming storm. Each moment the flashes were brighter and the thunder-claps louder. My brothers and sisters were also awake, and in the intervals of stillness I called to them across the hall. The storm was traveling at a rapid pace, and it was not long before it burst in all its fury over the house. The wind howled around the corners, the thunder roared, blinding flashes of lightning illuminated our rooms, and the rain and hail beat upon the roof. It lasted longer than most summer storms, but at length passed, leaving quietness behind it, and in the hush of the dawn we heard a stir in the parlor.

We did not wait to put on even our shoes, but in bare feet and nightgowns ran down, to find our parents already dressed, and the birds, awake, alive, fully recovered from the suffering of the previous day, collected at the windows, eager to get out.

"Oh, mama, can't we keep them?" we asked eagerly.

"No."

"Not even one?"

But our dear mother was firm. She had the strongest sense of the rights of animals, and she knew that no matter how kind we might be to these birds, they would never be so happy in captivity as in the wild freedom of the bush. So half reluctantly we opened wide the windows, and with *coos* and *caws* and various notes of ecstasy they flew joyfully forth into the sweet-smelling, rain-freshened world. We, too, felt glad with them, and rejoiced that they were free.

Though ever after on each hot summer day we hoped they might, the birds never again visited us; but I think they recognized our greater friendliness, and after that day were more tame, especially as father gave orders that no bird was to be shot near our house. Among all the sweet memories of my childhood, the day when the birds were our guests stands out as the most exquisite of all.

PHOTOGRAPHING A FLICKER FAMILY

BY WILLIAM LOVELL FINLEY

With pictures by Herman T. Bohlman

IF I were the owner of the Oregon firs about the reed-covered pond, I 'd rather take a lease from the flickers than from any other bird family. They 're not always a-moving south and leaving your trees without an occupant as soon as the first frost nips. When the thermometer drops low and the kinglets are twittering too softly to be heard more than a few yards away, "highhole" always sends a full share of bird cheer up and down the scattering woods. Nor is he half as particular as some of the bird residents. He takes the best of the few remaining stumps and seems satisfied. Once he pounded out a wooden home just below his last year's house. His wife did n't like it very much, but they settled it in some way and reared a thriving family.

"Redhammer" of the West, like "yellowhammer," his Eastern cousin, is a rather odd mixture of woodpecker and robin. The *Picus* family in general takes its food from the bark of a tree, but redhammer often feeds on berries, grain, and earthworms. According to woodpecker taste, a bird should cling to the side of a tree, clutching two toes above and two below, with body propped by his tail; but highhole is independent and often sits on a limb as an ordinary percher. Nature has given the flicker a bill slightly curved, instead of straight and chisel-shaped. But why does this Westerner parade the woods in a jaunty suit lined with red, while his Eastern cousin flaunts from tree to tree in a yellow-lined jacket?

Highhole is somewhat of a barbarian among the Romans about the pond. He knows nothing about, nor does he care for, the finer arts of architecture and music. A dark den suits him as well as a mansion. He has a voice like the "holler" of a lusty-lunged, whole-souled plow-boy. As he swings from stump to stump, his wings flash red like a beacon-light. He shouts "Yar-up! Yar-up! Yar-up!" from the tree-top, or occasionally he breaks the woody silence with a prolonged, jovial "Ha! Ha! Ha! Ha! Ha! Ha! Ha!" Sometimes he sounds a softer chord in his nature. In the spring I have often seen him hitch slowly up the stump to his favorite trysting-place, where he calls, "Zwick-a! Zwick-a!" to his mate.

With a tinge of regret I 've watched the clumps of fir thinned year after year. Highhole does not care a snap. He can bore a hole in a church steeple as easily as in a fir snag. The moral influence on his family is about the same in one place as the other. For two seasons I watched a red-shafted flicker rear his family in the tall steeple of a Presbyterian church in the heart of the city. Another flicker dug a home in one of the maples that border the walk about a large grammar-school. The poor hen was harassed half to death by attention from the boys, but she reared four lusty shouters.

I have known highhole for years. For two seasons we have photographed him and his family. He has punctured with doors and windows every old stump about the pond. Every one of these old boles is dead to the deepest root, yet I generally find them throbbing at the heart more vitally than the greenest neighbor in the clump. Redhammer is not altogether idle during the months of rain and snow. When he does work, he goes like an automatic toy wound to the limit. As soon as the weather brightens into the first warm spring-like day, he and his wife have a wooden house well near its completion.

"IN THE HOLLOWED HEART OF A CERTAIN FIR LAY SEVEN GLOSSY EGGS."

Few birds have larger families than the highhole. But were it not for the number of his family, how could he hold his own among so many enemies? His conspicuous size and color always makes him a shining mark to the collector, for every village lad in the land has collected flicker's eggs. He is a

fellow of expediency, however. If his home is robbed, his wife soon lays another set of eggs. It is on record that one pair, when tested by the

"WITH THE CAMERA READY TO SNAP, FIRMLY FASTENED TO A SMALL BOARD, WE CLIMBED THE TREE."

removal of egg after egg, laid seventy-one eggs in seventy-three days.

In the hollowed heart of a certain fir, on a bed of fine wood bits, lay seven glossy eggs, inanimate, but full of promise. They all had the vital flesh-tinge of pink. Each imprisoned a precious spark of life, to be fanned by the magic brooding of the mother's breast.

Redhammer had grown quite trustful. We got a ladder twenty-five feet long, which reached almost up to the nest. The eggs had been placed a foot and a half below the round entrance. On the opposite side from the entrance, and on a level with the eggs, we sawed out a back door, giving a good view of the living-room, and letting in a little sunlight. With the camera ready to snap, firmly fastened to a small board, we climbed the tree. Holding it out to a measured distance, we aimed it downward at the eggs. The first attempt came nearer landing camera and all in a heap in the shallow water of the pond, than getting a photograph of the eggs; but after several trials a good picture was taken.

Neither mother nor father flicker seemed exactly to understand our right of making free with their home. The former nervously returned to her nest each time we descended the tree. She climbed in the front door. It was easy enough to recognize her own eggs, but that new door was a puzzle. She had to slip out and examine it half a dozen times, returning always by the round door above. This modernized dwelling made her a little uneasy, but she soon settled down, satisfied to brood and watch her gossiping neighbors at the same time. After we fastened up the new entrance, flicker affairs went on as usual.

Some of our later visits were certainly a little tiresome for the brooding mother. A knock at

"THEY LIKED TO CLING TO OUR CLOTHING."

the foot of the tree was generally followed by an impatient eye and a dangerous-looking long bill at the threshold, the greeting a busy housewife gives an intruding peddler. With a bored look,

THE PARENT BIRD AT HIS FRONT DOOR.
(Copyright, 1903, by H. T. Bohlman.)

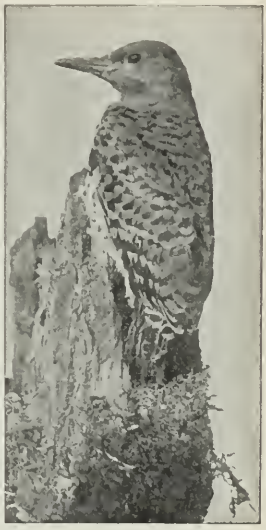
she flipped across the way and sat while the visitors nosed about and prowled in her house.

Those naked baby flickers were the ugliest little bird youngsters I ever saw.

In the heart of the fir the development was rapid. The thin, drawn lids of each callow prisoner cracked and revealed a pair of black eyes. Feathers sprouted and spread from the rolls of fatty tissue up and down their backs. Each bill pointed ever upward to the light. The instant the doorway darkened, each sprung open to its limit. The nestlings soon took to climbing the walls, not solely for amusement. The sharp ears of each youngster caught the scrape of the mother's claws the instant she clutched the bark of the tree, and this sound always precipitated a neck-stretching scramble toward the door. The young had little chance of exercising their wings; so the next time we climbed the tree with the camera, they were apparently full-grown, strong in climbing, but, to our advantage, weak in flying.

We are not likely to forget the day we climbed the stump to picture the young flickers. The full significance of the task had not struck us. Nor had the enjoyment of it dawned upon the fledglings. They were bashful at first, but after a little coaxing and fondling they were as tame as pet pussies. They climbed out and crowded the stump-top, where they sat in the warm sunshine, stretching, fluffing, bowing, and preening.

They liked to cling to our clothing. A coat sleeve was easier climbing than a tree-trunk, and it was softer to penetrate with a peck. There was a streak of ambition in the soul of each flicker that would put most people to shame. They climbed continually, and always toward the top. Up our arms to our shoulders they would go, and then to our heads. Just at the instant one's mind and energy were directed toward balancing in the tree-top, he was sure to get a series of pecks in the cheek. One might endure the pecks of the sharp claws as they penetrated his clothing now and then, but he would be likely to cringe under the sting of a sharp chisel-shaped drill boring with rapid blows into his arm.



"ON GUARD."

I could n't see any use in the parents working themselves to death feeding such ravenous full-grown children. "They might as well 'hustle' a little for themselves," I said, as I climbed the stump next morning. We took all five of the fledglings to the ground. Wild strawberries they gulped down with a decided relish until we got tired and cut short the supply. We soon had a regular "yar-uping" concert. One young cock clutched the bark with his claws, his stiff-pointed tail-feathers propping his body in the natural woodpecker position as he hitched nestward up the tree, followed by his mates.

Afterward, when I set all five on a near-by limb with the order, "Company, attention! Right dress!" they were the rawest and most unruly recruits I ever handled. If the upper guide did not keep moving, he received a gouge from his impatient neighbor below. This was sure either to set the whole squad in motion, or to start a family brawl, without regard to the aggravated patience of the bird photographer. "About face!" was executed with the same lack of discipline on the part of the feathered company. The captain stepped meekly around to the other side of the limb, and planted himself and camera in the rear.

During our early acquaintance the fledgling flickers savagely resisted our attempts to coax

them out of their home. After a few hours in the warm sunshine, they fought every effort to put them back. They were no longer nestlings, for a bit of confidence had transformed them into full-fledged birds of the world.

The following day a casual observer might have noticed that the flicker population of the fir woods had increased. Here and there, one caught sight of a bird bearing the emblem of a black crescent hung about his neck. Juvenile "Yar-ups" echoed among the scattered trees and over the pond. Occasionally there were flashes of red as wings opened and closed and a bird swung through the air in wave-like flight.

"COMPANY, ATTENTION!" FRONT VIEW.

REAR VIEW.

"THEY CLIMBED OUT AND CROWDED THE STUMP-TOP."

A GLIMPSE OF THE FOX COUNTRY.

PHOTOGRAPHING A WILD FOX

BY SILAS A. LOTTRIDGE

THROUGHOUT the wooded districts of Otsego County in New York State, west of the Glimmerglass, there are to be found a considerable number of foxes. The natural conditions for the protection and even increase of this species of wild animal exist there to a marked degree. Although the woodsman has worked great havoc among the pines, hemlocks, and chestnuts that once covered the high hills of the district, here and there even now may be found a comparatively large forest. The ground, when cleared, not being suitable for agricultural purposes, it has been allowed to run wild, and a luxuriant growth of scrub-oak, pine, and cherry, a few evergreens, and a tangle of brier have taken the place of the larger timber. The whole section, therefore, offers ideal homes for the foxes.

It was during the tapping of the sugar-bush that some boys noticed numerous fox-tracks in the snow. They also caught an occasional glimpse of a long, slim body gliding as silently as a shadow into the dwarf hemlocks by the swamp, and the watchers of the sugar-camp at night were often startled by shrill barking just outside of the circle of light. This reminded the boys of the gradual disappearance of their father's fowls and the oft-repeated threats against Reynard, and they determined, when the hurry of sugar-making was over, to turn their attention to the destruction of their troublesome neighbors.

The motive of my interest in the foxes was very different from that of the farmer and his family, with whom I was staying, so that my enthusiasm was less easily dispelled. I was bent, not on their destruction, but on learning more of their habits and real life—how they cared for their young and protected themselves from the many dangers that beset them—and on obtaining, if possible, some photographs of wild foxes.

One day, while in an old stump-lot which sloped south, I caught a glimpse of a large fox as he disappeared behind a knoll and then reappeared a little farther on. He trotted leisurely across the open pasture, never once turning his head or in any manner indicating that he had seen me. He was not fifteen rods away, and would have been an easy shot, but I would not have killed him for all the poultry in the farmyard. I immediately seated myself by an old stump and focussed my field-glass upon the beautiful animal. I had no sooner done this than the fox, which probably had been watching me all the

time, sat down, dog-fashion, and turned his gaze full upon me. For ten minutes there seemed to be an equal fascination between man and fox,

BAIT FOR THE FOX.

and then a sudden change came over the fox. My perfect quietness seemed to disturb him. His frequent change of position, the occasional opening of the mouth, and other quick, nervous movements, told very plainly of the strain he was undergoing.

During this time I had lowered the glass and was gazing intently at him, and never for an instant did he take his eyes from me. I was at a loss to know how to proceed, for I very much desired a closer acquaintance with this wonderful old fox, who had matched his wit against that of man and the trained hound. The fox evidently had a similar inclination, for he slowly raised himself, standing at full height for a moment, and then advanced probably fifty feet. Here he stopped an instant as if to reassure himself that he had made no mistake, and then trotted toward me, a little to one side of a direct line, and came to rest on a knoll above me, about six rods away. Thus he stood for fully a minute, keeping his eyes fixed on mine, and then, turning suddenly, he disappeared among the brakes. Before this I had known the fox only as a shy and cunning animal, but this one had shown another side. My attitude of friendliness toward him seemed to be reciprocated, and I believe that with me he had lost the fear that was so evident in his relations with other men.

I was now certain that his den and family could not be far away, so the next morning I led the dog to the place where I had met the fox on the day previous. Almost before I had time to remove the dog's collar, the fox appeared, not a hundred feet away. In a moment the dog had sighted him, and away they went to the south over the old course. I now devoted my time to a search for the den, and within twenty minutes stumbled upon it. It was strange that I had not found it before, as I had been within a few feet of it several times.

During the afternoon I laid plans for the further study of the old fox. The following morning I led the dog to the former place of starting. The fox appeared just as on the previous day, and away they ran over the course of the morning before. With field-glass in hand, I followed until I reached a point on the side of the ravine opposite the den, from which I commanded a full view of the valley below, as well as of the den. Here I concealed myself and awaited further developments.

A GOOD "FIND."

The sound of the hound's baying died away in the distance, and for about an hour the stillness was broken only by the occasional song of birds and the chirp of insects. Then again I heard the hound, and in a little while he appeared in sight in the valley below. He apparently had lost the trail, and so it proved, for in another half-hour he passed my place of concealment on the way to the house. I watched until the middle of the afternoon, but saw nothing more of the old fox.

WATCHING THE HOUND IN THE VALLEY BELOW.

The next day I repeated the experiment, and watched particularly for the appearance of the dog in the valley. I found that he lost the trail in about the same place near the creek. Sometime before this I had seen the fox coming up the creek near the den, which he passed, never so much as turning his head, and I soon lost sight of him among the ferns and low bushes. The dog worked the trail for some time longer, but finally gave it up and went to the house. By this time I thoroughly understood the action of the dog. Now I must watch for the fox. On the third day, as the fox and the dog started as before, I carefully watched the place where the dog had lost the trail. Two hours later I saw the fox, on his return trip, on the top of a stone wall, at the place where the hound lost the trail each time. The wall at this point was so near the creek that the fox could jump from the wall to the bed of the creek. The banks were low for some distance, and I could see him in the shallow water, making his way toward the den. As the banks became higher he was lost to view, and I turned the glass upon the creek, which was fully exposed near the den. In a little while he passed this point, and farther up the creek came out upon the high ground and seated himself near a stump, carefully surveying the valley below. At first he seemed very calm, but became more restless as the hound appeared in the valley. By the time the dog had reached the place where the fox had taken to the wall, the fox, in his apparent delight, lost all control of himself. He jumped and frisked about, and seemed to enjoy the perplexities of the dog with almost human inteiligence. As the dog became more and more bewildered, he gave vent to his disappointment at intervals in long-drawn howls. These seemed to electrify the fox, his hair bristled, and for a moment he looked very fierce; but almost instantly a change came over him, he lay down, opened his mouth, and fairly laughed as the dog became more and more puzzled. These varied scenes lasted

"THESE SEEMED TO ELECTRIFY THE FOX."

for half an hour, until the hound uttered one prolonged howl and gave up the struggle.

Thereupon the fox became quiet, resting in a

THE STONE WALL USED BY THE FOX IN ESCAPING FROM THE HOUND.

position half concealed by a stump, where he could watch every movement of the dog. After the dog had passed, the fox sat up on his haunches and watched him until he was out of sight, when, almost instantly, the fox turned and disappeared among the low bushes which skirted the maple grove.

This performance was repeated almost to the letter on the following day. The situation was now perfectly clear to me. The fox was on guard at the head of the valley, ready to lead the dog away, and, after completely fooling him, returned by way of the creek, and from his vantage-point at the upper end of the valley in the stump-lot watched with absorbing interest the perplexities of the old hound.

It was now time to attempt to photograph the fox; his acquaintance had been carefully cultivated, his method of deceiving the old hound studied, and his appetite satisfied with many a fat chicken. Knowing something of his resting-places at the head of the ravine, where he watched the hound in the valley below, and being supplied with a long-focus lens and a release to the shutter that could be operated from two to three hundred feet distance, I felt reasonably sure of success. The camera was properly concealed, and after about two weeks of constant work there were found among the numerous failures four fairly good negatives.

I saw nothing of the fox during the week which ended my stay at the farm. At night I sadly missed the barking that sounded from the grove or meadow, and sometimes even closer to my window; but I had a secret hope that the tamest of wild foxes was still active and—even, alack! at the expense of chickens and goslings—might long outwit those who sought his life.

THE STORY OF PLANT LIFE

No matter how many things there are in nature about which we can have at present no certain knowledge, of this we can be sure—that the first kinds of living things on the earth were plants. No kind of animal could have been first, for there is no kind of animal that can feed itself without the help of the plant. When life first appeared on the earth, there was nothing for it to feed upon but lifeless things, like air, and salt, and water; and the only kind of creature that can live on such things is the plant. What, then, are plants?

PLANTS ARE LIVING THINGS

That plants are living things is the first idea we must clearly form about them. They are living in just the same sense that we are. They were born from a seed, the joint product of two previous individuals, their father and mother. Plants likewise live by eating; they have mouths and stomachs, which devour, digest, and assimilate the food supplied to them. These mouths and stomachs exist in the shape of leaves, whose business it is to catch floating particles of carbonic acid in the air around, to suck such particles in by means of countless lips, and to extract from them the carbon which is the principal food and raw material of plant life. Plants also drink, but, unlike ourselves, they have quite different mouths to eat with and to drink with. They take in their more solid constituent, carbon, with their leaves from the air; but they take in their liquid constituent, water, with their roots and rootlets from the soil beneath them. "More solid," we say, because the greater part of the wood and harder tissues of plants is made up of carbon, in combination with other less important materials; though, when the plants eat this carbon, it is not in the solid form, but in the shape of a gas, carbonic acid. So far, it will be enough to remember that plants are living things, which eat and drink exactly as we ourselves do.

PLANTS MARRY AND REAR FAMILIES

Plants have two distinct sexes, male and female —sometimes separated on different plants, but more often united on the same stem, or even combined in the same flower. For flowers are the reproductive parts of plants; they are there for the purpose of producing the seeds, from which new plants spring, and by means of which each kind is perpetuated. The male portions of plants of the higher types are known as stamens; they shed a yellow powder which we call pollen, and this powder has a fertilizing influence on the young seeds or ovules. The female portion of plants of the higher types is known as the pistil; it contains tiny undeveloped knobs or ovules, which can only swell out and grow into fruitful seeds provided they have been fertilized by pollen from the stamens of their own or some other flower. The ovules thus answer very closely to the eggs of animals. After they have been fertilized, the pistil begins to mature into what we call a fruit, which is sometimes a sweet and juicy berry, as in the grape or the currant, but more often a dry capsule, as in the poppy or the violet.

Plants, however, unlike animals, are usually fixed and rooted to one spot. This makes it practically impossible for them to go in search of mates, like birds or butterflies, squirrels or weasels. So they are obliged to depend upon outside agencies, not themselves, for the conveyance of pollen from one flower to another. Sometimes, in particular plants, such as the hazels and grasses, it is the wind that carries the pollen on its wings from one blossom to its neighbor; and, in this case, the stamens which shed the pollen hang out freely to the breeze, while the pistil, which is to catch it, is provided with numberless little feathery tails to receive the passing grains of fertilizing powder. But oftener still, it is insects that perform this kind office for the plant, as in the hollyhock and the greater part of our beautiful garden flowers. In such cases the plant

usually makes its blossom very attractive with bright-colored petals, so as to allure the insect, while it repays him for his trouble in carrying away the pollen by giving him in return a drop of honey. The bee or butterfly goes there, of course, for the honey alone, unconscious that he is aiding the plant to set its seeds; but the plant puts the honey there in order to entice him against his will to transport the fertilizing powder from flower to flower. There is no more fascinating chapter in the great book of life than that which deals with these marriage relations of the flowers and insects.

HOW PLANTS START THEIR YOUNG ONES IN LIFE

Again, after the plant has had its flower fertilized, and has set its seed, it has to place its young ones out in the world to the greatest advantage. If it merely drops them under its own branches, they may not thrive at all; it may have impoverished the soil already of certain things which are necessary for that particular kind; and even where this is not the case, the surrounding soil may be so fully occupied by other plants that the poor little seedlings get no chance of establishing themselves. To meet such emergencies, plants have invented all sorts of clever dodges for dispersing their seeds. Thus, some of them put feathery tops to their seeds or fruits, like the thistle and the dandelion, the willow and the cotton-plant, by means of which they float lightly on the air, and are wafted by the wind to new and favorable situations. Others, again, bribe animals to disperse them, by the allurement of sweet and pulpy fruits, like the strawberry or the orange; and in all these instances, though the fruit or outer coat is edible, the actual seed itself is hard and indigestible, like the orange-pip, or is covered with a solid envelop like the cherry-stone. Numerous other examples might be given. We have to remember, then, that plants to some extent provide beforehand for their children, and in many cases take care to set them out in life to the best possible advantage.

Most of these points to which we are here briefly calling your attention are true only of the higher plants, and especially of land plants. For we must not forget that plants, like animals, differ immensely from one another in dignity, rank, and relative development. There are higher and lower orders; grades and classes; some big, some small; some annual, some perennial; some rooted in dry land, while some float freely about in water; some with soft stems like spinach and celery, while others have hard trunks like the oak and the chestnut. We must ask ourselves what were the causes which made them differ at first from one another, and to what agencies they owe the various steps in their upward development. In short, we must not rest content with merely saying that the rose is like this and the cabbage like that; we must try to find out what gave to each of them its main distinctive features. We must "consider the lilies, how they grow," and must seek to account for their growth and their peculiarities.

POINTS TO KEEP IN MIND

And now let us sum up again these central ideas. Plants are living things; they eat with their leaves, and drink with their rootlets. They take up carbon from the air, and water from the soil, and build the materials so derived into their own bodies. Plants also marry and are given in marriage. They have often two sexes, male and female. Each seed is thus the product of a separate father and mother. Plants are of many kinds, and we should learn how they came to be so. Plants live on sea and land, and have varieties specially fitted for almost every situation. Plants have very varied ways of securing the fertilization of their flowers, and look after the future of their young, like good parents that they are, in many different manners. Plants are higher and lower, exactly like animals.

These are some of the points we must keep in mind and study further about, if we are ever to become familiar with the wonders of plant life.

HOW PLANTS BREATHE

We must learn more and more of the wonderful way in which plants help to keep the world alive, and as we read we shall come to understand the great mystery of the stuff that makes the grass green. Without this we could not be alive. We know that all air contains carbonic-acid gas, which is poison to us and to all animals. But the plant has a secret which no man knows of; it can split up this gas and live on it, taking it into its own body and building up food for us to live upon. To do this the plant uses the greatest power in the world, the power of sunlight. The leaves of a plant are flat and thin, so that they can drink in as much sunlight as possible, and the power of the sun helps the green stuff to split up the carbonic-acid gas into two parts. One of these the plant eats itself, and the other it gives back to the air quite pure. If it were not for the plant's power of doing this there would

be no life anywhere, and the world would be as dead as a stone.

Let us now see what we mean when we say that a plant breathes. If we can understand this for a plant, we shall understand it for every living thing, including you and me. When we talk about breathing, we usually think of the way in which our chests move up and down, as we draw the air into our lungs when we are taking a breath, and then let it out again.

Now, a plant has no chest or lungs, and many animals have neither chest nor lungs, but yet they all breathe. It is not necessary that a living thing shall move up and down, or in any other way, in order to breathe. We do so; but that is because we breathe so very quickly, and because we have learned a special way of breathing that is very easy and successful. But all breathing is really one and the same, whether it is done by a plant or an oak-tree, by a fish or a man.

Wherever living things are to be found, whether under the water or out of the water, there must always be a particular kind of stuff called oxygen. This is a thing we may have never seen or heard of, and yet, whenever we see anything at all, we see through oxygen—because it is part, and the most important part, of what we call air. Oxygen is found in air, and it is also found in water. If a living thing lives in air, it has to get its oxygen from the air. If it lives in water, it has to get its oxygen from the water. The first plants did this because they lived in water, like many plants of to-day, and like crabs and fishes and many other animals. But later plants, like the flowering plants, moved out of the water on to the land, just as animals have done, and so they have to get their oxygen from the air, just as cats and horses and birds and men do.

Breathing is an act that has two parts, which go on backward and forward always; and the first of these two parts is taking in oxygen. Every living thing does this, and must die if it ceases to do it. But what is the second half of this act of breathing? You may well ask. Directly we think about it we shall see that the oxygen which is taken in by breathing must go somewhere, something must happen to it, and the simple fact is that the second half of the process of breathing always consists of giving back the oxygen to the air or to the water.

But if that were all, of course there would be no sense in it; it would not be worth doing. But the point is, that while the oxygen comes in alone, "by itself," it always comes out again with something else; and it is that which makes all the difference. This something else, though you could hardly believe it, is the same stuff as that which makes coal and diamonds and the writing part of lead-pencils, and its name is carbon.

When this carbon which the oxygen has found in the body of the animal or the plant is joined to the oxygen, it is turned into something which would look like oxygen itself if you could see it; but you cannot see it, however closely you look at any one when he is breathing. It mixes with the air, and though you cannot see it, you see through it, just as you see through oxygen itself. This new kind of stuff, like oxygen, and like the stuff which comes through pipes into houses, and is burned at the end of them, is a kind of gas, and the special name for it is carbonic-acid gas. Every living thing, from its first moment of life to its death, breathes in oxygen and breathes out this stuff which is made of carbon and oxygen, and which is called carbonic-acid gas.

Now, plants must do this because they are living things, and they cannot live without it. But this breathing is not one of the things that a plant is very good at. Indeed, a plant breathes just as little as it can and keep itself alive. It is quite easy to prove that a plant must breathe to some extent, at any rate, because you can suffocate a plant as easily and certainly as you can suffocate an animal. If you keep away all oxygen from an animal, you suffocate it, and it will die, and the same is true of a plant. If it does not have enough oxygen, and have it all the time, day and night, any living thing, from a microbe up to a man, will die of suffocation.

HOW PLANTS DO THE OPPOSITE OF BREATHING

Just because this is true of every living thing, we must not forget it in the case of the plant; but at the same time a plant needs far less oxygen than an animal, because it breathes much more slowly, and the curious thing, as we must now see, is that most plants are specially good at doing something which is just the opposite of breathing, something which no animal can do, and which every animal depends upon plants to do for it. The plants that do this wonderful thing that we are going to talk about are all green plants, or, at any rate, if they are not green, like grass, they are brown, like seaweed. But the little difference in color does not matter, for the stuff that makes the seaweed brown is really the same as the stuff that makes grass green. This stuff is so important that we must think of all plants in the world as divided into two great kinds—those which have this green or brown stuff, and those which have not. The first

kind we shall call green plants, and we must now talk about them very carefully.

Very nearly all plants are green plants, but we have already mentioned one or two that are not—such, for instance, as the mushroom. You never found a green mushroom or a green toadstool. The plants that have no green stuff in them are peculiar, so to speak. We must think of them as if they did not do what a plant ought to do; they have lost what is the most striking and important power of plants, and so for the present we can leave them out of account.

The green stuff of all other plants is really one and the same everywhere—even when it is brown, as in some seaweeds. It is the same stuff in a cabbage, a blade of grass, a leaf of a tree, or the scum of plants that forms on a still pool of water. It has a long special name — chlorophyll — but here we need not bother ourselves with that; we may just call it green stuff, or leaf-green.

WHAT THE GREEN STUFF DOES AND WHAT THE SUN DOES

This green stuff is most important because of what it enables the plant to do, and that is what we must now talk about. But we must begin at the beginning—and that beginning is not the green stuff itself, but the sun, the great and glorious sun. By itself the green stuff can do nothing; it is of no use to the plant, and is only a burden to it. Indeed, if plants are cut off from sunlight altogether, they die at once, or, at any rate, lose all the green stuff in them. It is the sun that makes the green stuff in the plant, and green stuff's only use, after it is made, is to help the plant to profit by the sun.

Now, this is just a tremendous fact, and we should make a very great mistake if we went on to talk about what the green stuff does without making quite sure that we understood what the sun does. Without the sun there would be no life at all upon the earth. Just as all living things depend upon each other, and just as they could not exist unless they were always serving each other, as we saw a little while ago, so the whole company of living things depends upon the sun.

Company is a very good word, because its real meaning, as you will learn again some day, is "the people who feed together." *Com* means with, or together, and *pany* really means bread. Your *companion* is really the little boy who *eats bread with you.* Now, all living things do their feeding with each other, with each other's help, and so we are very right in calling them a company; but without the sun none of them could feed at all, and they would all die. Indeed, it is really the light and power of the sun that we all feed upon, and the wonderful thing about the green stuff of the green plant is that, without the green stuff, we could not use the sunlight. First of all, the sun makes the green stuff in the green plant, and then uses it to feed the green plant and all other living things, including you and me, for we get all our food either from the green plants or else from the bodies of animals that live on green plants.

Without the sun there would be no life upon the earth; or, to put it very shortly and plainly, in a way that you ought to remember, *No light, No life.* We think it has never been put much more shortly than that, and yet, short as that is —no light, no life—it is absolutely true, and there are no exceptions to it anywhere, and never have been, and never will be.

IF THE SUN WERE TO GO OUT EVERYTHING IN THE WORLD WOULD DIE

The green stuff, then, though no life can do without it, is only an instrument, something the light uses to make life. If the sun were to go out—though there is no fear of that—all the green stuff in the world would not help us at all, and all the plants and animals would soon die. There was some excuse, you see, for the ignorant and untaught men of long ago who used to worship the sun. When we go out on a bright day and enjoy the light and warmth of the sun, we must remember that if it were not for this light and warmth we should not be here. This is true of us; it is true even of animals that live in the dark; it is true even of trees and fishes, and seaweed and microbes. Some of these creatures, like microbes, may be killed by sunlight, and they have to keep out of its way; so may we be killed by sunlight if it is too strong, and gives us sunstroke. But even microbes depend upon the sun for their life, for without the sun none of the things upon which microbes feed could possibly exist.

Now that we have learned how important the sun is, we are ready to look at the green stuff of the green plant with a new interest, since it is the means by which light can produce life.

THE REASON WHY A LEAF IS FLAT AND THIN

The tiny specks of green stuff which give the leaf its color are of the same green stuff that is to be found in other parts of plants besides the leaves. We know that the stem, or stalk, of a

rose is green. But most of the green stuff of plants is found in their leaves, and it is for the sake of the green stuff that leaves exist at all. The leaves of a plant are its tools for using the green stuff. Directly we think of a leaf we see that it is made in a particular way. It is a flat, thin thing. So much are leaves flat, thin things that we call other things which are flat and thin "leaves," though they are not parts of a plant at all—the leaves of this book, for instance. The first books were made of real leaves.

Now, there is a very good reason why leaves should be flat and thin. Leaves exist in order to expose as much green stuff as possible to the light. If a leaf were shaped like a ball, only the green stuff on the outside of it, and, indeed, only the green stuff on the side of it which was turned to the sun, could receive the sunlight. All the rest would be in darkness, and that is as good as to say that it would be quite useless. If you like, you may try to think of some kind of leaf that would expose its green matter to the sun in a better way than the leaves you know. But you will not succeed. Perhaps you never asked yourself before why a leaf is shaped like a leaf; but the question is worth asking, and the answer is that no other shape can be even thought of that would be so useful.

WHAT THE SUNLIGHT DOES WITH THE GREEN STUFF

The object of a leaf is to expose as much green stuff as possible to as much sunlight as possible, and it does this perfectly. Of course, a leaf must have two sides, and if one side is exposed to the sun, the other must be in the shade. But, then, leaves are usually so very thin that the sunlight can go right through, and so none of the green stuff is wasted.

Sometimes, when leaves have to be rather thicker, you will find that as little green stuff as possible is wasted, for now almost all the green stuff is packed on to the upper side of the leaf, which is dark green; and if you turn it over you will find that the under side is hardly green at all. Green stuff is of no use where it cannot get the sunlight. But you see how well things fit in with each other, for the green stuff is made by the sunlight in the first place; it is made where the sunlight strikes the leaf, and is made just where it can be useful.

And now we come to something rather more difficult; but it is not too difficult for us, and it is very important, for it is necessary to all life. We have agreed that there is something which the green stuff does by means of the sunlight, or, better still, there is something which the sunlight does by means of the green stuff. Now, what is it?

HOW PLANTS EAT

We should know all we can of the way in which a plant lives upon air. None of us could live without air, but all that we do is to breathe air. The great secret of the plant is that it can eat air and live upon it. The green stuff in the plant is made by the sunlight, as we have seen; it is made where the sunlight strikes the leaf; and when it is made the green stuff uses the sunlight to do a remarkable thing. It takes the carbonic-acid gas that is in the air and splits it up into two things—carbon and oxygen. The carbonic-acid gas is poison, but the plant splits it up and makes it into food, not only for itself, but for us. That is what a plant does with the sunlight, and it is, perhaps, the most perfect use of power in the world.

If we go back to what we said about the plant's breathing, we shall remember that the plant is surrounded by air. We have seen that this air contains oxygen, which is a gas, but it also contains many other gases, for the air we breathe is nothing else than a mixture of gases. Now plants, as well as animals, breathe air, but all green plants do also what no animal can do—they eat air. The gas in the air which plants eat, or feed upon, is, curiously enough, the same gas as that which the plant gives out while breathing—carbonic-acid gas. We have already seen that this carbonic-acid gas is made up of two parts—carbon and oxygen. Carbon is important not merely because it makes diamonds and coal and lead-pencils, but because it is one of the things that are always necessary as part of the food of living creatures, animal or vegetable.

All air contains a small quantity of carbonic-acid gas, which is partly made up of carbon. So far as animals are concerned, this gas is a poison. If there is any more than only a very little in the air, we die, so far are we from being able to make any kind of use of it. One of the difficulties of our life in houses is to keep the air fresh—that is to say, to prevent it from having too much carbonic-acid gas in it.

But this stuff, which is poison for us and for all animals, is food for the plant; and, if it were not food for the plant, there would be no risk of it poisoning animals, for there would be no animals for it to poison. That is the way in which living things depend upon each other. Now, the great question is: How does the plant manage to make food for itself out of this carbonic-acid gas? The gas itself is of no use to the plant,

any more than it is to us. We have already seen that the plant gets rid of it when it breathes, just as we do, and to take it back again as it is would doubtless kill the plant, just as we should be killed if we went on breathing our own breath—or other people's—over and over again.

The only way in which the plant can get food out of the carbonic-acid gas is to split it up into the two things of which it is made—carbon and oxygen, to keep the carbon, which is good food, and to give back the oxygen to the air. This, you see, is exactly the opposite of what the plant does when it is breathing. Now, the plant only does this in daylight, because it depends upon the sun for its power to do it; but though it only does this in daylight, while it breathes all the time, day and night, yet it breathes so slowly and it does this so quickly, when it does do it, that in the long run it takes from the air far more carbon than it gives to the air, and builds up this carbon into its own body. That is why it grows and how it grows; and a plant goes on growing all its life, while little boys and girls, as we all know, go on growing for only a few years, and then never grow any more.

That is really one of the greatest differences in the world between animals and plants, and it entirely depends upon this great power that the plant has of taking carbonic acid from the air, splitting it up into its carbon and oxygen, giving back the oxygen to the air, and building up the carbon into its own body. Every green plant does this all its life for so much of every twenty-four hours as there is sufficient light in the sky. As it is building the carbon up into its own body, it fixes the carbon on to other kinds of stuff in such a way as to make things which animals, including ourselves, can eat.

THE MOST IMPORTANT THING WE KNOW ABOUT PLANTS

All animals, like all plants, require carbon, but if we were left with nothing but the carbonic acid in air to get our carbon from, in a coal-mine, with tons of carbon all round us and tons of lead-pencils and millions of dollars' worth of diamonds, we should die of starvation in a day or two. There would be enough carbon around us to keep I do not know how many thousands of animals alive, if only it could be used. But we should be like the foolish king in the story who wished everything turned into gold, and then found that though everything was gold and worth a great deal, it was worth nothing to him, for you cannot live by eating and drinking gold. Just in the same way animals—which must have carbon or die—cannot live on diamonds or even on the carbonic acid in the air, and the most important fact about green plants is that they can take the carbon from the carbonic acid in the air, can live on it, and turn it into their own bodies, and then give those bodies as the food without which the whole animal world, including even ourselves, must surely die.

THE WONDERFUL WORK THAT THE GREEN STUFF DOES

What about the green stuff again? What does it do? Well, the answer is that without it none of this could be done. Let us see what it is exactly that happens. Carbonic-acid gas, as we have seen, is made up of carbon and oxygen, and these two things are joined very powerfully together. Unless you are a green plant, it is one of the most difficult things in the world to separate the carbon and oxygen of carbonic-acid gas from each other. They are so powerfully joined that it needs very great power, used in just the right way and at just the right moment, to separate them, and then, if you are not very careful and clever, they will join together again before you know where you are. All this is supposing that you are not a green plant. It is only quite lately, even since little boys and girls were born, that men have learned, with great difficulty and expense, and long preparation and a great deal of danger, to separate carbon and oxygen from each other when once they have joined to form carbonic-acid gas. But if you are a green leaf it is quite different.

The green stuff in the green leaf has no power of itself, and you understand that it is power which is wanted in order to separate things which are powerfully joined together. The more tightly a nail is stuck in a wall the harder you must pull to get it out.

HOW THE PLANT USES THE STRONGEST POWER IN THE WORLD

Now, there is no power in the world stronger than the power of sunlight. The plant knows this, and men know it, too. So, when they try to separate carbon from oxygen, men naturally use the power of sunlight in order to overcome the power with which the carbon and oxygen are holding on to each other; and, of course, men can help themselves to sunlight just as well as the leaf can—and much better. They can store it up and turn it into other shapes, and then let it loose, so to speak, in far greater power than the leaf ever has any chance of using—that is to

say, men can use far more sunlight at a given moment than the leaf ever gets a chance of using at a given moment. Between two ticks of a watch the leaf only gets a certain small amount of sunlight, even on the brightest day in summer in the hottest part of the world, where the sun is shining straight down upon it. Now, men can store up sunlight in hundreds of different ways, so that between two ticks of a watch they can use, if they like, millions of times more than the leaf would receive in the whole of its lifetime.

THE DIFFERENCE BETWEEN HAVING POWER AND USING POWER PROPERLY

But it is not enough to have plenty of power—you must know how to use it, or how to apply it, or how to direct it. If the power in a steam-engine is properly used, it will draw a train or take a great boat across the ocean; but if it is not properly applied or directed, it will go its own way and may kill thousands of people. This difference between having power and using it properly is true of everything—green leaves and steam-engines and everything else—and a whole library of books might be written on just this one little truth. It is really one of the greatest truths in the whole world.

Money is power, and great things may be done with it. With enough money a man might save millions of lives every year; but we all know that it is not enough to have money in order to profit by it. You must know how to use it, how to apply it, how to direct it. Many people nowadays have plenty of money, and all they do with it is to destroy themselves and destroy or make miserable thousands of other people. Then, again, to be clever is power; but that power is worth nothing unless it is properly used, applied, or directed. One of the cleverest men who ever lived was called Napoleon. His cleverness was so powerful that if it had been properly applied it might have made the world into a better and happier place for all ages to come; but he did not know how to use his cleverness or power, and so he caused the death of at least eight million men, women, and children, destroyed the happiness of countless millions more, and died wretched and in prison. That is the difference between having power and knowing how to use it.

Now let us go back to the green leaf we were talking about. The sunlight which pours down upon it is power. Clever men, all gathered together, after making long preparations, can help themselves to far more power than the green leaf can get, but they cannot apply it, and so they can scarcely do what the green leaf does. The green stuff in the green leaf makes it able to apply all the sunlight it gets to the business in hand, which is to split up the carbonic-acid gas of the air into its carbon and oxygen, and to keep the carbon for the use of the plant. This is done without any noise, without any fuss, without any machinery, without great heat, without any waste at all, and without any wear and tear of anything.

In the whole wonderful world we know of nothing to beat this for the perfect way in which power is put to use. It is not merely the best, it is perfect, and without it this glorious earth, with all its wonders of life—trees and fish and birds and men—would be as dead as a pebble. So if you are a little boy you might do worse, when next you run out into the garden, than take off your hat to the sun above you and the grass upon which you tread.

Though you are, beyond words, more wonderful and greater than either of them, and though they are so wonderful themselves just because they make little boys possible, yet who will dare to deny that even little boys owe them wonder and awe and love?

HOW WE LEARNED ABOUT PLANT FOODS IN THE AIR

It is still a common belief that the great bulk of all plants comes from the soil, and this belief is considerably strengthened when first-class gardeners constantly recommend trenching or deep digging, as well as manuring. When one sees the oaks, beeches, elms, pines, etc., of our country, the giant trees of California, and those of Australia—gum-trees—many of them nearly 500 feet high, one can hardly imagine the great bulk of these trees to have been derived from the small quantity of carbon floating about in the air we breathe. Such, however, is the case. The great mass of tissue in a plant is secured, not from the soil, but from the atmosphere.

The old philosophers, including Aristotle, taught that all the nourishment of plants came from the soil alone. This doctrine was accepted without question for centuries. At last a learned Belgian physician, named Jan Baptista van Helmont, who was born in Brussels in 1577, entertained doubts as to the accuracy of this teaching. To settle the matter he commenced experimenting. He planted a willow, which he had previously carefully weighed, in a pot containing 200 pounds of soil. He watered the plant daily with rain-water. The willow flourished, and at the end of about five years' cultivation he weighed

the plant and soil again. The willow had gained 164 pounds in weight, but the soil had only lost two ounces! It was therefore obvious that Aristotle and the others had been all wrong. It was impossible for the 164 pounds of wood, leaves, etc., to be made out of the two ounces of soil.

Helmont was puzzled, and eventually came to the erroneous conclusion that the extra weight could only be obtained from the water he had given the plant. He had no idea of the numerous minute pores or stomata on the under surface of the leaves, nor of the fact that carbonic-acid gas was absorbed from the atmosphere during the daytime, and oxygen liberated. This discovery was made 200 years later by a Dutch scientist, Jan van Ingenhousz, who published his researches in 1779.

HOW PLANTS DRINK

We know, then, that plants, for the most part, eat with their leaves, and that they grow, on the whole, out of the air, not, as most people seem to fancy, out of the soil. Yet you must have noticed that farmers and gardeners think a great deal about the ground in which they plant things, and very little, apparently, about the air around them. What is the reason for this curious neglect of the real food of plants, and this curious importance attached to the mold or soil they root in?

That is the question we shall have to consider now; and we shall answer it in part at once by saying beforehand that, though plants do grow for the most part out of the carbonic acid supplied by the air to the leaves, they also require certain things from the soil, less important in bulk, but extremely necessary for their growth and development. What they eat through their leaves is far the greatest in amount; but what they drink through their roots is nevertheless indispensable for the production of that living green stuff, which is the original manufacturer and prime maker of all the material of life, either vegetable or animal.

Plants have roots. These roots perform for them two or three separate functions. They fix the plant firmly in the soil; they suck up the water which circulates in the sap; and they also gather in solution certain other materials which are necessary parts of the plant's living matter.

The first and most obvious function of the root is to fix the plant firmly in the soil it grows in. Very early floating plants, of course, have no roots at all; they take in water and the dissolved materials it contains, with every part of their surface equally, just as they take in carbonic acid with every part of their surface equally. They are all root, all leaf, all flower, all fruit. But higher plants tend to produce different organs, which have become specially adapted by natural selection for special purposes. If you sow a pea or bean you will find at once that the young seedling begins from the very first to distinguish carefully between two main parts of its body. In one direction, it pushes downward, forming a tiny root, which insinuates itself with care among the stones and soil; in the other direction, it pushes upward, forming a baby stem, which gradually clothes itself with leaves and flowers.

The tip of the root is the part of the plant which has the greatest aptitude—so much so that Darwin likened it to the brain of animals. For it goes feeling its way underground, touching here, recoiling there, insinuating little fingers among pebbles and crannies, and trying its best by endless offshoots to fix the plant with perfect security. Large trees, in particular, need very firm roots, to moor them in their places, and withstand the force of the winds to which they are often subject. After every great storm, as we know, big oaks and pines may be seen uprooted by the power of this invisible but very dangerous enemy.

The root, however, does not serve merely to anchor the plant to one spot, and secure it a place in which to grow and feed; it also drinks water. The hairs and tips of the root absorb moisture from the soil; and this water circulates freely as sap through the entire plant, dissolving and carrying with it the starches and other materials which each part requires for its growth and nourishment. Without water, as we all know, plants will wither and die; and the roots push downward and outward in every direction in search of this necessity of life for the leaves and flowers.

Plants, then, drink by means of roots. But they take up by them, not only water, which is their needful solvent, but also other materials urgently required for their growth and development. The most important of these materials is certainly nitrogen, which forms a most needful part of protoplasm, the living matter that scientists call the "physical basis of life," the thing without which no plants or animals could be possible. Nitrogen is also necessary to the making of leaf-green. Where, however, the roots do not supply nitrogen in sufficient quantities, plants procure it for themselves by means of their leaves or stems, and therefore become insect-eating or flesh-eating.

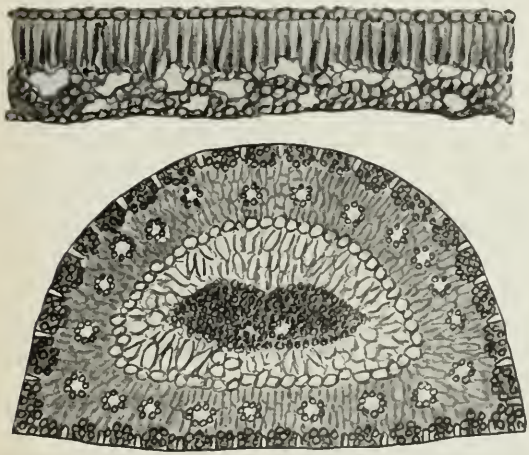
Roots, however, have other functions besides drinking water and sucking up with it certain

dissolved materials; the chief of these other functions are fixing the plant securely in the ground, and affording a safe place of winter storage for starches and other surplus foodstuffs.

WONDERS OF A GREEN LEAF

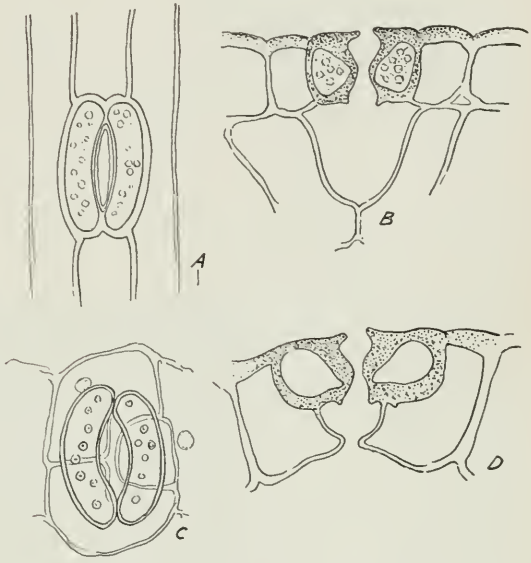
With the advent of spring the sap begins to rise, the buds to swell and the leaves to unfold. This annually recurring condition of things we accept as such an ordinary and commonplace occurrence that it attracts no notice. One would as soon think of giving heed to the fact that plants have leaves as to specially notice that animals are covered with hair, birds with feathers, and that fishes have scales. Nevertheless, a close look at a green leaf and a careful study of its structure and functions will afford us many happy and instructive moments.

Few of us ever think of a green leaf as a breathing, living organism, but, in some respects, such is a fact. Of course, leaves do not breathe muscularly as animals do, but the diffusion of the air through their structure in a way suggests animal breathing. In the surfaces of leaves there are many tiny holes with well-balanced valves that are extremely sensitive to external conditions. These are the breathing pores of the plants and are called stomata. These stomata belong especially to the green parts of plants but have been found on all parts except the roots.



These two illustrations show the cellular structure of the edge of leaves when cut through. The upper one is deadly nightshade, a close cousin to the potato and egg-plant. The lower one is a section of a pine needle. The little white slits around the edge are the breathing-pores. The circular white spots in the greenish-gray part are the resin-ducts.

They have the power to open or close, as acted upon by the proper influence. In the light they remain wide open, but darkness causes them to close. The application of water will usually cause them to close, but in certain orchids and lilies, strangely enough, quite the opposite effect



ENLARGED VIEWS OF STOMATA OR BREATHING PORES

A is top view of hyacinths and B is cross-section of the same. C is a view of stomata on a plant of the stonecrop family and D its section. Both cross-sections are more greatly enlarged than the top view.

is the case. These, however, seem to be not the rule but quite exceptional cases.

When an animal breathes, it is the oxygen in the air that is retained and a gas called carbon dioxid that is thrown off. Plants do this also to a certain limited extent, difficult for any one but a botanist to understand, but in the main, when a leaf breathes, it is the carbon dioxid that is used and the pure oxygen that is returned to the air.

If you can examine a thin section of a leaf through a microscope, you will see that it is composed of a number of cells of various shapes and sizes. Usually, the cells along the lower side are more scattered and have air-spaces among them. With the exception of the outside layer of cells, forming the "skin" of the leaf, these tiny cells contain minute granules of a green-tinted substance, called chlorophyl. It is this substance that gives the green color to the leaf. When air comes through the stomata and circulates among these cells, the carbon dioxid that it contains is decomposed by this chlorophyll. The oxygen is returned to the air but the carbon is retained and with the water is sent to various parts to form wood, fruit, nuts, berries, etc.

SOME CURIOUS INSECTS AND THEIR HABITS

THE MOSQUITO

"Buz-z-zip-pah! Hateful screen-n-n-now I. 'm through-oo-oo. D-d-dinner-r-r! Ah-here!"

WHACK!

"Buz-z-z—narrow-s-s-scape-that!—z-z-z—here 's-another-place-to-z-z-zettle.—Ah!"

Everybody knows the song that the mosquito sings, varied, of course, to suit occasions; but listen a bit, keeping in mind the surroundings, and you can translate it easily enough. It may be the bad boy's tough cheek that is the burden of the refrain, or the little girl's tender cheek; it may be mama's white forehead, or papa's ear, or baby's dimpled hand. That song always presages evil, and the worst of it is that it is not always a solo, but often a chorus. There are some things that make us exceedingly angry, and yet the next moment seem funny or ridiculous. The mosquito is one of these things. Over the exasperating bloodthirsty, disease-spreading pest we can get justly wrathful until we long for something to descend on each and every winged nuisance and put them all out of existence. But the lively little wriggler larvæ, the water-babies of this insect, with their funny antics, are only amusing until we call to mind that in a short time they will become mosquitos; and then perhaps the oil-can promptly pours its contents upon the surfaces of their habitations. There is nothing that gives a better opportunity to practise consistency than one's opinions of the mosquito. Generally ignorance or carelessness interferes. We hate the pests; often they cannot be tolerated; we do what we can for the moment to get away from them—retreat within the house and quickly close the screen door after us, and the tiny little foes shortly squeeze through the screen and get at us in spite of our wire guards.

And all this fuss when, with very little trouble, we might go calmly about and be altogether rid of the pests. Just interest the neighbors in the same idea! Let everybody see that no stagnant water exists near by, fill up or drain the natural little pools, overturn the tomato-cans, broken pitchers, bottles, old rubber shoes, and anything else that can catch rain-water; or if swampy ground, rain-barrels, tanks, watering-troughs, or surface cisterns cannot be avoided, either pour some kerosene on their surfaces, say three or four times during the summer, to spread over as a film; or if the water is to be utilized from above, just put in a few little fish of any kind—minnows, sunnies, or baby perch. Then watch for results. If this plan is carried out consistently in any mosquito-ridden neighborhood, there will be no more mosquitos in that section for some time, although each year these preventive measures should be resumed.

Mosquitos are numbered among the many insects that live an aquatic life during their imperfect stages as larvæ and pupæ. The female lays her eggs, from a hundred to several hundred, in a boat-shaped mass on the surface of water. In twenty-four hours, if the weather is warm, the eggs hatch, the tiny wrigglers wriggling out of the lower ends of the upright eggs into the water below. They feed upon minute algæ, diatoms, and animalcules, and every now and then wriggle to the surface, head down, to breathe air through their air-

A FEW HOMES OF MOSQUITOS.
Almost anything that will hold water is acceptable.

MOSQUITO EGG "BOAT," OR "NEST." (MAGNIFIED.)

The eggs are placed on end and packed closely together on the surface of water, or on wet earth where puddles occur. Sometimes as many as 400 eggs are in one mass.

tubes. They grow very rapidly. Three times, finding their skins will not stretch as fast as they grow, they discard them for new ones, after the manner of many other kinds of larvæ, such as caterpillars. In about a week or ten days they go through a remarkable change, from the larva to the pupa form, casting their wriggler stems off altogether and turning back up instead of tail up. With little round, fat bodies and heads all in one, and curved tails with paddles, they go to kicking and jumping instead of wriggling. They do not now feed at all, but require more air than before, and get it through two little air-tubes that look like ears sticking out of their backs, and they spend much time at the surface for the purpose. If frightened, they give a vigorous kick which sends them down to the bottom, though they float to the surface again at once unless they keep on kicking.

MOSQUITO LARVÆ WRIGGLERS AND PUPÆ JUMPERS ALONG THE EDGE OF A POND.

In such places they are generally protected by the dense grass. A "wolf" in the fold, in the shape of a little chub-minnow, which might seem to the mosquitos a veritable monster, forces its way into the retreat, and gobbling up the wrigglers wholesale, soon rids the place of them. Thus is the little fish one of man's best friends.

In two or three days they again become almost inert, and their backs, projecting a little out of water, crack open, and out of each one comes a regular full-fledged mosquito. Putting legs out first and standing on the water or on the pupa skin, it draws its body up and out into the free air. At first it seems limp and soft and its wings are small and milky white. In a few moments it becomes darker in color and more active, and, its wings expanding and stiffening, it rises in the air and flies away—ready for its prey, an active enemy of the human race.

There are many erroneous ideas concerning the mosquito. It is commonly said that mosquitos "bite." The impression is also common that grass, weeds, and shrubbery are alone responsible for their existence. As a matter of fact, the male mosquitos are not bloodthirsty; their appetites, if they have any, are more gentle and peacefully inclined.

MOSQUITO EGGS, AND LARVÆ HATCHING FROM THEM. (MAGNIFIED.)

Only the females "bite," and they do not really bite. They have no teeth for biting. It is a piercing and blood-sucking act they perform, quite as bad, no doubt, as biting, but not accurately described by that word in a scientific account.

While they find shelter in the low herbage, mosquitos depend absolutely on water or very moist earth for existence, though winds will sometimes blow them quite a distance away from water and in great numbers. This explains the fact, often noted, that a town or village near the sea is sometimes visited for days by hordes of these insects, and again is suddenly freed from them when the wind shifts to the opposite point of the compass.

MOSQUITO LARVÆ WRIGGLERS. (MAGNIFIED.)

Those at the surface are breathing air through their air-tubes.

Mosquitos have many enemies; bats and birds, and, more than these, dragon-flies catch countless numbers of them. But these are not to be controlled, though they should be protected.

If we wish to wage relentless war on the mosquito, that not only annoys us but endangers our lives by carrying diseases—for it appears to be the sole cause of malaria and in tropical countries of yellow fever—we must call upon the agents that are destined to exterminate the pests in time. Of these methods the principal are, kerosene on the water, filling up the stagnant pools with earth, dis-

A FAVORITE "NESTING"-PLACE OF THE MOSQUITO.

The eggs are laid on the surface, and the young mosquitos swim in the water.

carding rain-barrels, and putting fish in the small ponds to eat the larvæ. The dragon-fly and many other water insects feed upon the mosquito larvæ and thus aid us in keeping down the numbers of mosquitos.

It is to be hoped that some day the national and the state governments will appropriate large sums of money to combat and destroy the mosquito. This has been done in certain sections, as in New Jersey, South Carolina, Havana, Cuba, etc. But it must be done everywhere at once to be successful, else the insects will be carried from infested to "exterminated" regions by means of boats, trains, etc.

MOSQUITO PUPÆ. (MAGNIFIED.)

The one at the surface on the left is breathing air through its air-tubes. The one on the right has completed its transformation, and the adult mosquito is coming out of the pupa skin through a slit in the back. Its wings will soon expand and dry, and it will fly away to seek food.

to secure varying degrees of heat and humidity, they are viscid on their surfaces, so they will stick together and thus be easily transported in numbers at a time. This labor-saving provision is even more strangely shown in the tiny grub-like larvæ which hatch from these eggs. They are provided with numerous hooks over their bodies, so they may be stuck together like so many cockle-burs and moved about in clusters of a dozen or more at a time by the attendants of the nest.

These clusters of larvæ are not just thrown together in any haphazard manner, but are carefully placed with their mouth-parts all outside of the cluster, so that each may easily be fed. This would not be the case if any had their mouths within the cluster and hard to get at. It is during this larval period that the growth takes place to the size of the adults in the nest. It now passes to the pupa stage—a period of inactivity and rest. It now appears as an ant with its legs close to the body, and is pure white in color. These pupæ may be inclosed in thin silken cocoons spun by the larvæ just before going into this state, or they may remain uncovered. No ant grows any after this stage is reached. Shortly before they awaken from this sleep they turn dark to about the same

A MOSQUITO EXPERIENCE.

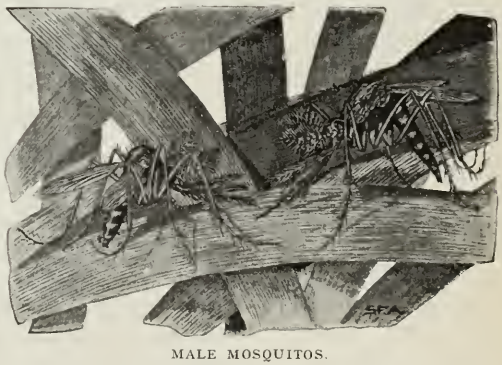
She approaches, expectant, on bloody business bent, "singing" a high-pitched, joyful song. She alights upon the investigator's sleeve, and the song ceases. She likes not the sampling thereof, and removes, the song continued, to the willing victim's finger-tip. She proceeds to business, and fills herself with blood and the finger with itching, whereat, rejoicing exceedingly, she hastens away, singing again, and lays numerous eggs in the rain-filled tomato-can.

CURIOUS HABITS AND STRUCTURES OF ANTS

The wonderful and queer little insects, the ants, do so many strange things that the naturalists are divided in opinion as to whether they have merely instinct or are actually possessed of reason and intelligence.

Ants are closely related to the wasps and bees. With them they form the order of *Hymenoptera*, which the naturalists consider the most highly specialized of all the orders of insects.

Even in their early infancy the ants excite our wonder. The eggs in a nest resemble tiny pearls, and as they must be moved about in the nest



MALE MOSQUITOS.

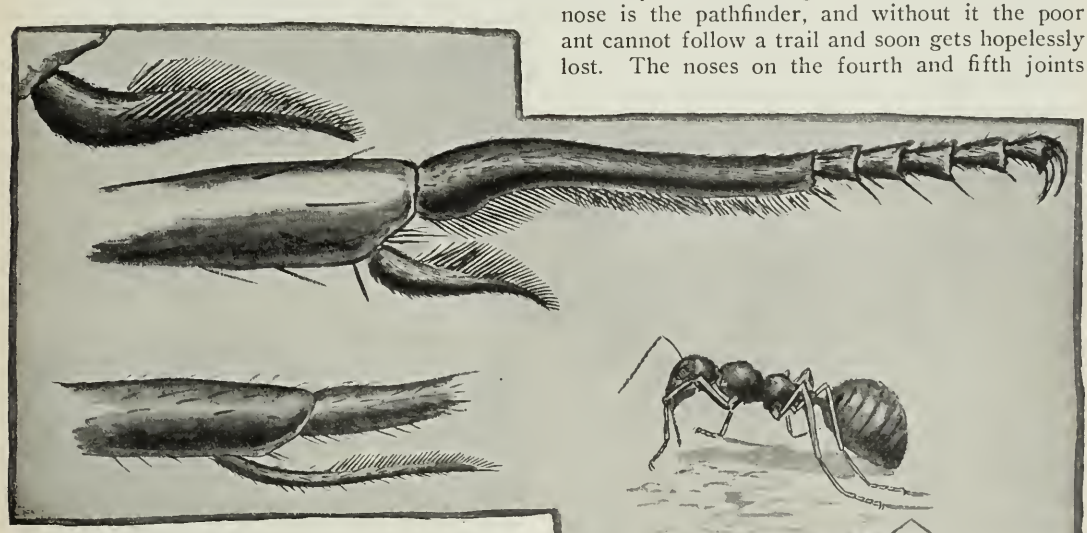
These plumed "dandies," though hard to see and find, are common about the matted grasses, rank weeds, and bushes in low meadows and damp woods, never far from water. They subsist mostly on vegetable matter and sweets.

color as the others in the nest. Those little brown pellets you see the ants carrying about when a nest is disturbed are not "ant eggs," as so many carelessly seem to think, but are these tiny cocoons.

In the matter of some of their sense-organs, the ants are more than ordinarily endowed. Strange as it may seem, each ant has at least six ears. Aside from this multiplicity of ears, they are located in just about the queerest place imaginable—on the legs.

They seem deaf to all sounds made by the vibration of the air, but detect the slightest possible vibrations of solid material. This is supposed to be to their advantage, in that such things as approaching footsteps tell more of the possibility of danger than such sounds as are transmitted through the air. So sensitive are their feet that they detect the impact of a small bird-shot dropped on the table from a height of about six inches and about fourteen feet distant from an artificial nest placed at the other end of the table.

As curious as are their ears, their noses are



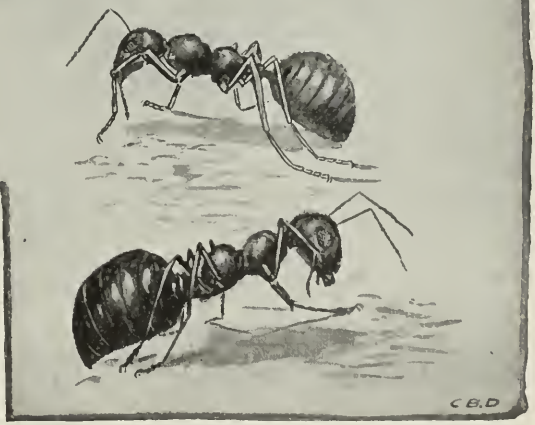
COMBS AND BRUSHES ON THE LEGS OF ANTS.

even more extraordinary. As the ants spend most of their time in the dark, they must depend largely on scent for their guidance, and, in consequence, have quite an elaborate array of noses, each for a special purpose. Miss Adele Fielde believes that their antennæ, those slender, thread-like appendages on their heads, are composed of a number of noses strung along in a line. Still more strange is the fact that each of these noses can smell only a special thing. It is just as if you had a nose to smell pickle and another to smell jam, and the pickle nose could not smell jam nor the jam nose smell pickle, and so on for a number of different things. The nose on the

GALLS ON OAKS FROM WHICH THE HONEY-ANTS GET THEIR STORES.

These galls are produced by one of the *Cynips*, a tiny gall-fly. The nectar collects in tiny white globules on the surfaces of the galls which still contain the immature fly.

tip or first joint of the antenna, it is said, is for recognizing the odor of the home; the one on the second joint is to recognize relatives. The third nose is the pathfinder, and without it the poor ant cannot follow a trail and soon gets hopelessly lost. The noses on the fourth and fifth joints



The upper ant is cleaning her antenna. The lower one is brushing her hair.

are for recognizing the eggs and immature ants in the nest.

No creature is more tidy than an ant, who cannot tolerate the presence of dirt on her body. These little creatures actually use a number of real toilet articles in keeping themselves clean.

ROTUNDS OF THE HONEY-ANTS
A worker is feeding from one of the rotunds.

No less an authority than Dr. McCook says their toilet articles consist of coarse- and fine-toothed combs, hair-brushes, sponges, and even washes and soap. Their saliva is their liquid soap, and their soft tongues are their sponges. Their combs, however, are the genuine article and differ from ours mainly in that they are fastened to their legs. The pictures show these combs and brushes and how they are used. The ants have no set time for their toilet operations, but stop and clean up whenever they get soiled. This is a hasty clean-up, just as we should do if something were spilled on us. A more extensive and leisurely toilet is made when they feel in a loafing mood, and they then lend a "helping hand" to one another in the cleaning-up process.

In their manners, their customs, their acts, and in various other ways a colony of ants suggests a community of tiny people. We can hardly say that the ants imitate us, for they lived and had their being long ages before man existed. They do many things that we do under similar circumstances, but allowance must be made for them, and we must not be too hasty in ascribing to them the operation of reason in their doings.

As most of you perhaps know, the ants are divided into a number of castes, consisting of queen, males, and workers. The workers are also specialized for a certain kind of work, and in some species there are several kinds of these, known as majors, minors, and minims, and each has its own work to do. Those fellows with the enormous heads, whose only duty is to fight, constitute the standing army of the nest. The others, the minors and the minims, have charge of the nest and see that everything is in order.

Some of these little creatures have their herds and flocks and manufacture paper from wood-pulp.

They have been known to collect the eggs of certain aphids in the fall, care for them in the nest during the winter, and replace them the following spring on the food-plant, so as to hatch into aphids and insure a supply of honeydew, of which all ants are very fond. They have been known to house these aphids in earthen structures built around them on the stems of the plants. Whether this is to prevent straying or is for protection is not known. They are also builders of subways.

Then there are those queer honey-ants, some of whom are but living storage tanks wherein is kept the honey-supply of the colony. This honey is mainly collected from certain galls on oak-trees by the outside workers and fed to these "rotunds," as they are called, whose sole duty is to receive this honey and hold it until needed by some of the others in the nest for food or to feed to the young ones. The one who wishes a supply of honey puts his mouth to the mouth of the rotund and drinks as you might drink from a faucet. Should one of these rotunds be crushed, the others eagerly lap up the wasted sweet; but if one should die, the globule of honey held by her is inviolate and is thrown upon the rubbish-heap in the nest, where all the waste of the nest is thrown.

Ants hold slaves and have their servants. Certain species of ants are known as slaveholders, from the fact that they raid the nests of other

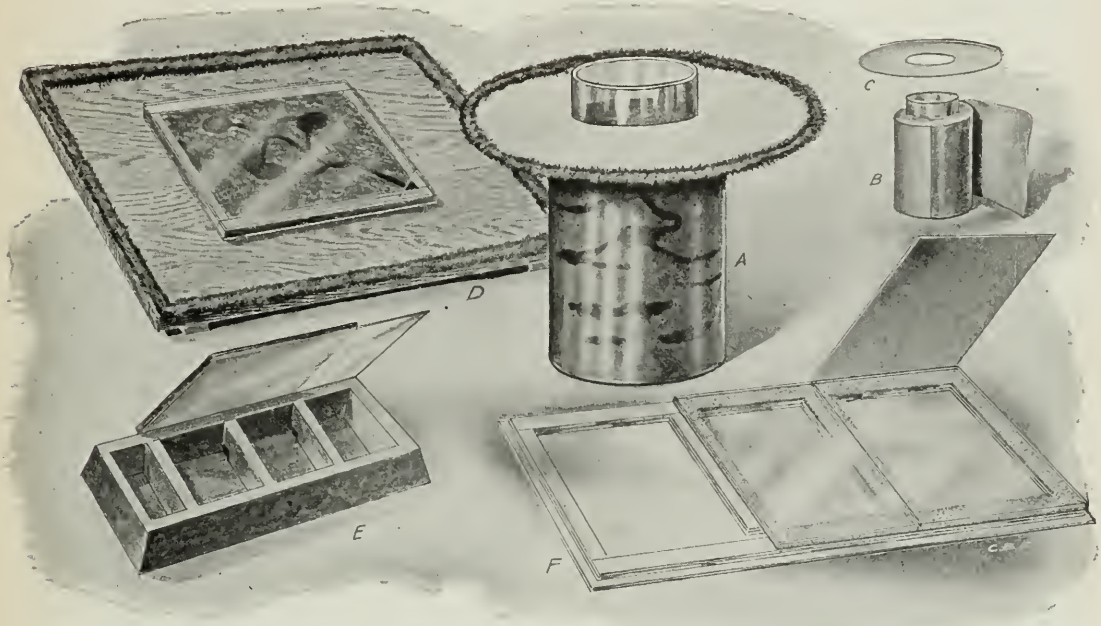
A ROOM IN THE NEST OF A HONEY-ANT
Rotunds clinging to the ceiling, which is left rough to give good foothold. These rotunds are almost helpless and are moved about by the workers, as shown on the floor.

ants and capture larvæ and pupæ, which they bring to their own nest and raise. The condition of these slaves is not real slavery, for they have full liberty to go and come as they please, and as

they have known no other nest, this is home to them. In this case it is the masters who are the worse off, for some have become so dependent on the ministrations of their servants that they are helpless without them and will starve with food all around if there are no slaves to feed them. This is an extreme case, for there are other slaveholders who are perfectly able to care for themselves in all ways. The extreme case is perhaps the final condition that slavery induces, and the others have not yet been reduced to that helpless state but may come to it later.

A great many of the interesting secrets of ant life could never have been found out had it not been for the use of the artificial nest, which enabled the observer to study these little creatures in their home life. You may verify a number of the strange things recorded about ants with one of these artificial nests, which is not hard to make.

The simplest is merely a jar with a wide mouth, nearly filled with earth and wrapped around with opaque paper. The ants to be observed are placed in here and soon excavate their galleries, some of which are against the sides of the jar if they are covered with something to keep out the light. By temporarily removing the opaque covering the ants may be studied. Another nest is the one devised by Sir John Lubbock. It is made of two pieces of window-glass held apart by thin strips of wood and filled in with sifted earth slightly moist. A corner of



VARIOUS TYPES OF ARTIFICIAL ANT NESTS.

A is a common, wide-mouthed jar filled with earth up to the neck, with a disk of tin or wood put on snugly around the neck. The outer edge of the disk is bordered with fur to prevent the ants straying away. This disk is their playground and where the food is put for them. *B* shows how the jar should be wrapped around with opaque material like black cloth or heavy dark paper. The disk *C* is shown above, ready to fit on the jar. The excavated galleries are seen in cut of large jar *A* with cover-paper off.

D is the Lubbock type of nest and consists of a board about eighteen by twenty inches, with the bordering of fur to keep the ants from escaping. The frame on the middle of this board is made of two pieces of window-glass separated by narrow wooden strips. They should be only about as thick as the queen. If too thick the galleries will not be seen. The space between the strips is filled with damp earth sifted in till just the thickness of the strips, and slightly pressed and the top scraped off even with their upper surfaces. The top glass has a corner cut off as shown, to make an entrance for the ants, who soon commence their excavating. This glass box should be covered with a piece of felt when not examining the ants, for they do not like the light in their nests.

E is the porous stone nest. The farthest cell to the left is filled with water. The other three cells have a communicating passageway through the division walls as shown. All these three must be covered with glass to keep the ants at home. The two central ones must be kept dark. The end one farthest from the water-cell is the food-room and ought to be light.

F is the type of nest used by Miss Fielde. It is made of a glass bottom with walls of glass strips cemented around its edges. Strips of toweling are glued to the tops of these walls to give ventilation. The room farthest to the left shows the glass walls and the passageway leading past the end of the partition into the other rooms. There is a passageway past both partitions. The two farthest cells to the right show the toweling tops to the walls, with cover-glasses in place, and the cell farthest to the right shows opaque cover ready to be put on. The ends and sides of this nest should be covered with black cloth to prevent light from passing through the walls. The whole nest is then placed upon a piece of white blotting-paper, which serves as a good background and as a cushion, too. A separate cover-glass goes over each cell. The one over the food-cell should be white. The others are better if yellow. A flake of moist sponge should be kept in the "living-rooms," but not in the food-room. Ants must have humid atmosphere to live in. Partition walls should be twice the width of other walls, so the cover-glass can fit down the center of it and still have good bearing surface.

the top glass is broken off to allow entrance for the ants. This part is placed on a board and surrounded with a moat of water or a strip of fur to keep the ants from straying away.

The best one, perhaps, is the nest devised by Miss Adele Fielde. It is made of a large pane of clear window-glass, with a wall of two thicknesses of double thick glass around it. This wall is half an inch wide and is topped with a strip of toweling to give the little inmates plenty of ventilation. A piece of damp sponge is kept in this nest, for the ants need a humid atmosphere. The cover-glass that is laid on this to keep the ants in is better made of orange-colored glass, for then no opaque cover need be used, as would be necessary if the cover-glass were clear.

The pictures show these nests plainly enough for you to build one for yourself if you so wish.

THE GARDEN SPIDER AND HER ENEMIES

NATURAL POSITION OF *ARGIOPE RIPARIA* IN WEB.

The zigzag line is supposed to be put in for strength. The white object at lower right hand is a grasshopper wrapped in a broad band of silk.

Toward the close of September you may notice, in the tops of the weeds at the side of the road, a number of reddish-brown objects, like tiny inverted balloons, and about the size of small hickory nuts. These are the cases that contain the eggs of the big, black-and-yellow spider (*Argiope riparia*) that one finds standing with her head downward in the large circular webs so frequent among the bushes. This is the one which, when disturbed, shakes the web so rapidly that both spider and web appear to be little more than a blur. She is supposed to do this either to capture the intruder, or else to protect herself from an enemy.

THE EGG-CASE OF *ARGIOPE RIPARIA*.

At A, with side cut away to show position of the "basket of eggs." At B is shown the "basket of eggs" removed, with the top raised to show the eggs inside.

In these egg-cases, which are fastened to the bushes by strong threads, the spider has made a warm, dry shelter for her young. Put a few of them under an inverted tumbler and you may have some interesting experiences, and make some interesting observations.

If all goes well the eggs will soon hatch. Now the food problem confronts the little spiders, for they must still remain for several months in the egg-case, or until the weather is warm enough

A, the egg-case containing the cocoons of the larger parasite. At B is shown the large parasite. C shows the smaller parasite.

for them to come out, and they settle the question by eating one another. When spring arrives the few that remain are large enough to care for themselves. This habit of eating one another continues throughout their lives.

THE ICHNEUMON-FLY LAYING HER EGGS, PIERCING THE COCOON.

The cocoon is firmly fastened in the weed-top by the strands of web in all directions.

With sharp-pointed scissors we will open one of these egg-cases, for the interior is interesting. Near the center is a tiny silken basket with a flat, close-fitting top, and in it are the eggs—nearly a thousand of them, says Dr. H. C. McCook. The space between this "basket of eggs" and the outside waterproof cover is filled with loosely spun brown threads. In the spaces among these threads the young spiders live, and probably hide to protect themselves from their hungry fellows. To make the outer covering, the mother spider uses the broad silk band which she employs to wrap around her own captives. This is the normal condition, but later in the season some of the cases will, perhaps, show a totally different state of affairs. The basket is now flattened against

THE LARGE AND THE SMALL PARASITES UNDER A GLASS WITH THE EGG-CASES.

the outer wall and has in it only some white chaff, while the case itself is almost filled with a spherical cluster of silken cocoons adhering tightly together. We know that young spiders never spin cocoons, but here they are. How did they get here?

When we ask Mother Nature a question we must needs wait patiently for the answer. Put this cluster of cocoons under the glass with the others, and in the spring you will find your answer in the form of pretty little black flies with orange-colored legs banded with black. These belong to the family of ichneumon-flies. If you are fortunate, you may see, in the fall, a fly repeatedly stinging one of these egg-cases. She is laying her eggs on the inside, and when the young are hatched they will devour the little spiders and then spin the mysterious cocoons.

The mother spider uses the broad band of silk in weaving the outside covering to the egg-case.

Probably before these ichneumon-flies appear you will notice some tiny flies, not more than one sixteenth of an inch long, flying around inside of the glass. These are secondary parasites which have devoured the young of one of the larger bees after it had spun its cocoon. Look closely and you may see minute apertures about the size of pinholes. These were made when the secondary parasites escaped.

Should all the spiders survive until spring, they would still have a very uncertain chance of living until the frosts of early autumn put a natural end to their lives. Birds and toads eat them in large quantities, but perhaps their greatest enemy is the mason-wasp that builds the mud cells on the rafters in the garret. The wasps capture them when they are but half-grown, paralyze them by stinging, and pack them into their cells to serve as food for the young wasp. When we consider the thousands of their enemies, we readily understand why so many eggs were packed into the little basket. It was necessary if Nature wanted any spiders to escape.

DRAGON-FLIES AND THEIR PICTURESQUE HOME IN THE MARSHES

WATER-INSECTS AND HOW TO MAKE AN AQUARIUM FOR THEM

Not long ago I kept a red-tailed hawk through one entire summer. But what has this to do with insects? You shall see. Among the various animals upon which these hawks feed, frogs are captured about as often as any others, and as they were easier for me to kill than birds or squirrels, for reasons which all bright boys and

girls will easily guess, I every day searched for this form of food. The best place proved to be a little pond at the edge of a wood, and while exploring it for my special prey I found insects in astonishing number and variety. Now you see how my hawk led me to study them.

WATER-STRIDERS

They may often be found on the water among lilies or other aquatic plants.

From at first merely glancing at these tiny animals, I finally came to feel a kind of friendship for them. Soon I was looking for certain bugs which I believed I could distinguish from others of the same kind, just as you know one of your kittens or pigeons from another. The whole vast world of insects had a new interest for me.

In nearing a pond we shall first see dragon-flies. All of them are so harmless that we may handle them without gloves. Their dreaded instruments (if they ever had any) for sewing up our ears and eyes are now lost—"needles in a haystack." No naturalist has been able to find

AN INSECT AQUARIUM

Showing the glass covering and general arrangement.

them! So we may sit in a shaded spot and watch serenely these dragon-flies (which, by the way, are the hawks of the insect world) as they dart about catching innumerable little flies of different kinds.

Most of us may have seen whirligig beetles (*Gyrinus*), those little black "water-bugs" which swim round and round in clusters on the water. Water-striders, or "skaters," as we used to call them, are also common. But it will pay to watch these insects more closely, and we should catch specimens of both kinds for an aquarium to be described later.

Now let us search for small insects which rest back downward just at the surface of the water; these are the back-swimmers. You may always know a back-swimmer by the long hind legs which project out from the body like oars from a boat and serve as oars to the insect. Catch some of these oarsmen with your net before they swim to the bottom of the pond, and be careful that they do not pierce your finger with

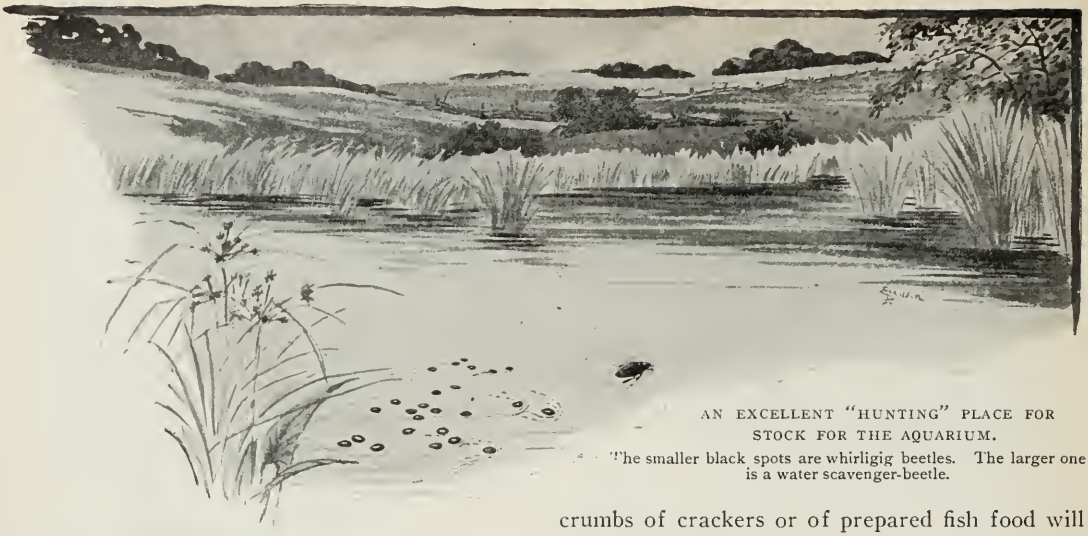
A GIANT WATER-BUG AND A "WATER-TIGER"

their sharp beaks. These and many of the others fly so well that to keep them in the collecting-can we should cover it with muslin.

Water-boatmen are interesting creatures easily found on the pebbled bottom of a pond. They are scarcely half an inch long; the fore legs, projecting from the sides, remind one of the wings of a penguin.

Diving-beetles, water-tigers, water scavenger-beetles, water-scorpions, giant water-bugs, and chrysalis of damsel-flies may be taken in the net by carefully sweeping the water near the bottom and about the roots and other submerged parts of water-plants. Still other species are to be found. But in one day we can capture enough of those named to interest and instruct us for many weeks.

For an insect aquarium a round, all-glass, gold-fish jar is just the thing. A "battery-jar" also does well. Place sand in the bottom of the vessel,



AN EXCELLENT "HUNTING" PLACE FOR STOCK FOR THE AQUARIUM.
The smaller black spots are whirligig beetles. The larger one is a water scavenger-beetle.

and in it put water-plants. Put in a layer of gravel, then fill about three fourths full of rain-water. To keep insects from flying or crawling out of the aquarium, it should be covered with cheese-cloth. The water need not be changed if stocked with the water-plants and with only such insects as are found in still ponds.

The food may consist of flies and very small pieces of raw meat, and it requires care to see that the food does not remain and decay but is all eaten. A few days' experience should teach you the right amount. You will at first be much more likely to feed them too much rather than not enough. They are so much smaller than our usual pets that we find it difficult to realize how

THE HOME OF DAPHNIA AND CYCLOPS.
One each of the tiny forms enlarged (within the circle).

small an amount of food one insect will eat. Ordinary goldfish furnish a convenient comparison. Most young folks will recall how very few crumbs of crackers or of prepared fish food will serve three or four goldfish two or more days.

It is interesting to multiply such comparisons, and this practice is the best possible way to impress upon our minds the size of these small creatures. In the pond mentioned at the beginning of this article the largest insect found was the water scavenger-beetle, shown in our picture. There may have been, and I suppose there really were, many of these beetles in the pond. Being two inches long, he was a giant indeed when compared with the majority of his neighbors, yet even to this huge insect the pond, which I could have crossed at its widest part in a running jump, was as a lake, the reeds on its edge like forest trees to us.

However, we have no knowledge that objects look larger to insects than they do to the very large creatures. The great compound eyes of an insect, such as the dragon-fly, often as large as the remainder of the head, must give their owners a peculiar idea of the size of objects. The slow, droning beetle is traveling at a speed which compared to his size is what the speed of an express-train is to us humans.

A COMMON DIGGER-WASP AND ITS PREY

On the prairies and bad lands of the southwestern United States and down through Central America, there is an enormous blue-bodied, red-winged wasp, known as *Pepsis formosa,* that makes a victim of the great hairy tarantula, *Mygale hentzii.* It is a battle royal well worth seeing, though rarely witnessed. In the Eastern States we have its counterpart, no less exciting though the contestants are much smaller in size.

There are several genera and species of digger-wasps. The commonest are the long, slender-bodied caterpillar-killers, *Ammophila*. Another

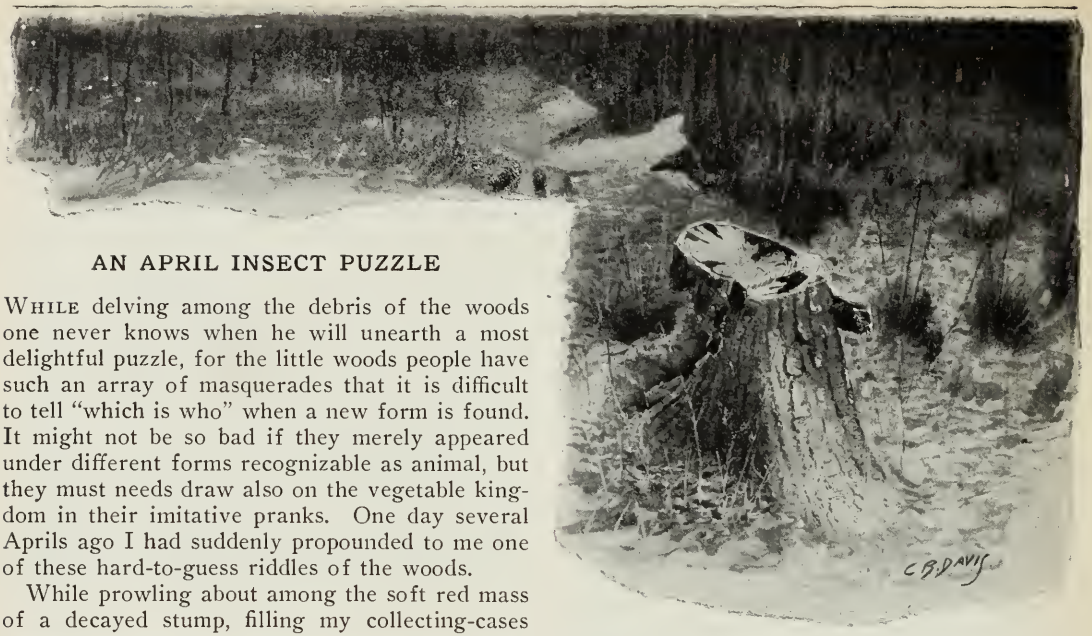
THE BLUE DIGGER-WASP STINGING A GRASSY BANK SPIDER.

common group are spider-killers, comparatively short-bodied wasps, generally blue-black in color, some species possessing red or white markings. It is one of these, *Pompilus philadelphicus,* that the writer had the good fortune to observe killing the common grassy bank spider, *Agalena naevia*. This is the little fellow from one half to three quarters of an inch in length, buff- and brown-striped, that builds a gossamer cobweb with a funnel retreat generally in grassy hillsides, fence corners, about stumps and roots and such like places. The wasp attacks the spider generally when it is beginning its web or crawling through

THE BLUE DIGGER-WASP ATTACKING A GRASSY BANK SPIDER.

These spiders average about one half an inch in length; the wasps about five eighths of an inch.

the grass in search for a place to spin, for it is rarely able to catch the spider when its funnel is within reach. The wasp also attacks other spiders, such as species of *Lycosa* and sometimes the jumping and crab spiders. When these spiders are attacked and cannot retreat, they always show fight, just as the Western tarantula does; but the wasp rarely hesitates to make the attack, carrying the spider off its feet by its sudden onslaught, and nearly always stinging it under the thorax. Having stung the spider into a state of insensibility, the wasp drags its victim to its nest in the ground and stores it away as food for the baby wasps when hatched.



THE APRIL INSECT PUZZLE WAS FOUND IN THE POWDERED, DECAYING WOOD AT THE LOWER LEFT SIDE OF THE STUMP.

AN APRIL INSECT PUZZLE

WHILE delving among the debris of the woods one never knows when he will unearth a most delightful puzzle, for the little woods people have such an array of masquerades that it is difficult to tell "which is who" when a new form is found. It might not be so bad if they merely appeared under different forms recognizable as animal, but they must needs draw also on the vegetable kingdom in their imitative pranks. One day several Aprils ago I had suddenly propounded to me one of these hard-to-guess riddles of the woods.

While prowling about among the soft red mass of a decayed stump, filling my collecting-cases

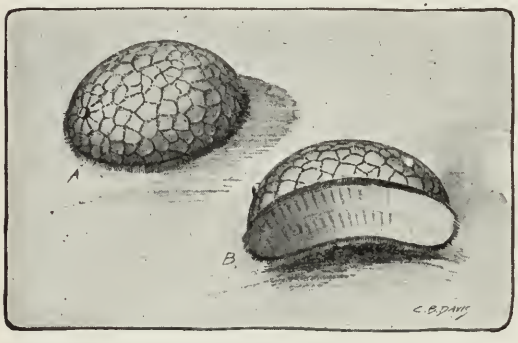


FIG. 1. *A*, UPPER SIDE; *B*, UNDER SIDE OF THE PUZZLE. (ENLARGED.)

FIG. 2. *C*, APPEARANCE FROM THE TOP; *D*, FROM UNDER SIDE. (CLOSE VIEW.)

with all sorts of queer things dear to the heart of a naturalist, I found what seemed to be a single fruit from a two-seeded capsule or pod. What first attracted my attention was its general "queerness," so I "collected" it and decided to put it in my sketch-book. A good representation of it is shown in Fig. 1, where *A* shows the upper side of it and *B* the under side. Before the sketch was finished I noticed that the object had moved. I thought I had jostled it, so replaced it in position and continued at work. On again looking at it, I saw that it was once more "out of pose." Special interest at once flamed up, for I knew that I had found, not a mere seed, but a prize and a puzzle. The question now was whether this was an adult or an immature creature. Hours were spent at my books with no success, and the attempt at identification was temporarily postponed to give the creature a chance to show if he were larva or if he were full-grown. Referring to my note-book, I find:

April 2. Found in decayed stump a queer affair about the size and shape of "sow-bug." Leathery in feeling, with convex side covered with dark-brown, bead-like network (*A*, Fig. 1). Fine, bristly fringe all around edge. At one end is what seems like a short stub of a stem, from which network radiates. Under side is softer and more moist. Returned to stump and secured some of the decayed wood for the little creature to develop in.

April 7. The queer animal is a poser. I have not the slightest idea as to what he may be.

April 16. "Queer bug" has changed from light brownish yellow to deep brown all over and is appar-

ently dead. At opposite end to the stub of stem are two light spots almost like a pair of eyes.

April 18. A short horn protrudes from each of the eye-spots on "queer bug."

April 19. No apparent change in "queer bug." Microscope shows shadowy form inside, about as *C* in Fig. 2 when seen from top, and *D* when seen from below. What seems to be the head is directly under the horns.

April 29. Apparently no change in "queer bug."

May 7. The enigma has emerged from its case and appears to be either a fly or a bee. Do not know which yet, as wings are badly crumpled.

This was later identified as *Microdon,* one of the syrphid flies, whose portrait appears in Fig. 3.

These larvæ of the *Microdon,* a genus of the family of *Syrphus* flies, live in ant-nests, and, when first found, were actually described as new genera of the mollusks or shell-fish. They are now recognized, however, as the larvæ of the *Syrphus* or flower-flies, so called from their food, which is the nectar and pollen of flowers. Perhaps the most common of the syrphids are those bee-like little fellows you may see any frosty fall morning benumbed on the chrysanthemums, but which soon buzz merrily about in the warm sunshine.

FIG. 3. THE FULL-GROWN FLY CALLED *MICRODON.* (ENLARGED.)

THE SELF-DEFENSE OF UNARMED INSECTS

MANY insects apparently entirely unarmed for the fight for existence have means of defense that are very interesting and unexpected. The harmless-looking caterpillar above is a good example.

The quiet, inoffensive-looking worm-like larva in the upper figure became a very demon in appearance upon being touched up with a stick. The decorative spots along the back culminated in a larger one on the shoulders which became a fierce and terrible "eye," and two flame-colored horns were thrust up where there was not the slightest sign of them before the attack. At the same time a drop of acrid fluid was discharged from the mouth. Its rampant and drawn-back attitude thickened it to twice its normal size. It seemed to swell out with fierceness, making a terrible-looking creature out of an apparently unarmed insect.

THE HARMLESS-LOOKING CATERPILLAR ASSUMES A FORMIDABLE ATTITUDE.

REVIVING A TIRED HONEY-BEE

This shows a bee beaten down by a heavy rain — exhausted.

THE honey-bee is proverbially industrious. When everything goes well with it, no form of animal life has more vigor, works more zealously, or defends its home more bravely. But the bee

soon loses its activity when separated from its home so that it cannot return, as, for example, when it gets into a room and fails to find its way out. Cold, rain or lack of food also soon puts it into a feeble or exhausted condition, making it appear as if it were discouraged. But nearly all of its usual activity may be restored by a little sugar or honey. Sweetmeats mean even more to it than to the young folks, for they not only give the bee pleasure but life. In the first of the accompanying illustrations is shown a bee exhausted by a beating rain, and by isolation from the hive; in the second it is seen applying itself to the restorative—a moistened lump of sugar.

In a cold, wet season, or when, for any other reason, honey-bees cannot gather nectar from the flowers, to convert into honey, and there is a shortage of food for the bees, the beekeeper

This shows how he "braced up" when given a lump of sugar.

feeds them with a syrup made of water and granulated sugar.

The nectar of flowers is practically sweetened water plus the peculiar flavoring of the particular plant from which it is taken.

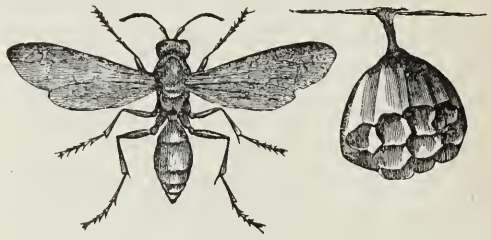
Honey-bees are fond of sweets in almost any form. I have placed ordinary candy, especially that in the penny stick form, within hives of honey-bees and found that the candy was eaten very rapidly. Honey-bees sent through the mails are supplied with food consisting of a hard paste candy, a mixture of sugar and honey.

WASP-NEST HUNTING IN NOVEMBER

Autumn is the best time for almost any nest-hunting. Then birds' nests may be collected without injury to the birds. Nests are more easily found when the leaves have fallen.

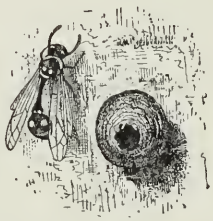
Late autumn is about the only time when wasps' nests may be collected with safety to ourselves; because but few of the wasps are then living, and those few are inactive from the cold.

Some boys recently told me that they had been



A WASP. THE WASP'S NEST.

wasp-nest hunting earlier in the year. But they went well protected with mosquito-netting over their heads and tucked firmly under collars of well-buttoned coats. Then they drew a stocking over each hand well up on the arm and put on



SOLITARY WASP AND ITS NEST.

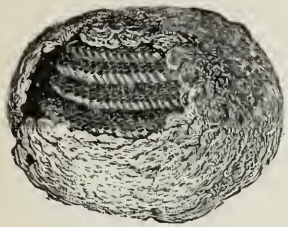
mittens. With such protection there is not much danger. The principal part of a wasp's nest is the comb—something like that made by the honey-bees, but differing in that it is made of wasp-paper instead of wax. The comb also con-

THIMBLE-SHAPED CELL BY WASP *AGENIA*.

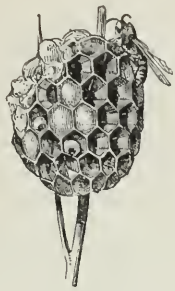
a, cell constructed by the wasp; *b*, female wasp. The vertical line shows natural size. The females build curious mud-cells under logs or under the bark of trees, provisioning them with spiders.

sists of one layer of cells, rather than two as in the honeycomb. In some species of wasps, the comb is of one layer of cells, with a "stem" at the back by which it is suspended from some sup-

port. In others the comb is inclosed with a spherical envelop of wasp-paper. Sometimes the nests are very complicated—a series of the single combs one above the other. The enveloping sphere or paper consists of several layers, as in the large nests of the hornets.



NEST OF PAPER-WASP.



NEST OF SOCIAL WASP.

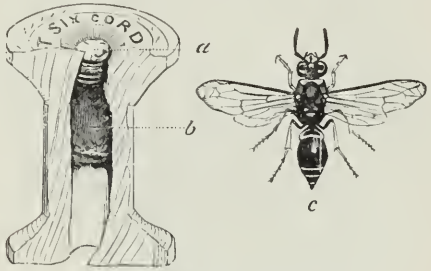
Wasps' nests are in all sorts of situations—some on the branches of large trees, some on shrubs, some under boards and stones, and others in the ground.

Herewith is a rough sketch of a queer nest of the wasp *Ischnogaster mellyi,* found in Asia and Java.

QUEER NEST OF THE WASP ISCHNOGASTER.

HOW INSECTS BREATHE

Insects cannot breathe through their mouths as can most of the higher forms of animal life, nor

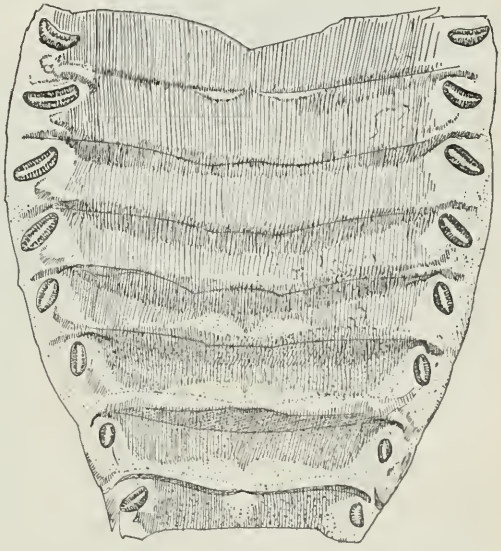


NEST IN A SPOOL BUILT BY THE POTTER-WASP.

a, mass of tempered clay used by the wasp to close the nest in a wooden spool; *b*, one cell of the nest; *c*, the wasp.

do they have their breathing-openings near the mouth.

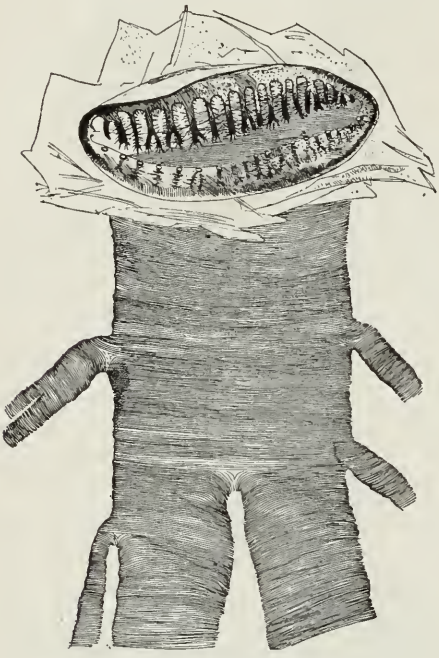
The early part of the insects' lives is chiefly spent in eating, and their mouths are so largely engaged in this work that it would not be possible to use them also for breathing; while to have their nostrils in the immediate vicinity of their mouths would be very inconvenient. They must therefore be supplied with air in some other way.



THE "NOSTRILS"—THE BREATHING-HOLES ON THE SIDE OF A CRICKET.

Accordingly Mother Nature has little breathing-openings on the various segments of which their bodies consist. Scientists call these openings spiracles. Hold a locust between your fingers and watch the breathing movements of the

body. Professor Packard says: "There were sixty-five contractions in a minute in a locust which had been held between the fingers about ten minutes." How does that compare with the number of breaths you take each minute? Insects of swiftest flight breathe most rapidly.



THE BREATHING APPARATUS OF AN INSECT
(SPIRACLE AND TRACHEA)

Each spiracle is guarded by little projecting spines which form a latticework or grate to keep out dust, etc. After passing through the spiracle the air is conducted to all parts of the body by tubes made by tiny spiral threads. This microscopic tube is something similar in form to a curl of hair made by brushing the hair around a curling-stick and then pulling out the stick.

HOW INSECTS HIDE

Although insects are more numerous than all other land animals put together, yet we do not, in a general way, see so many of them as we might reasonably expect. Of course many simply hide themselves underground, amidst foliage or rubbish, in chinks and crannies, or in gloomy corners. To find insects that are hidden in this manner is not very interesting.

We wish to discover how insects, without putting themselves out of sight, take up such a position with regard to the objects around them—their environment, as it is called—that they can with difficulty be seen, even by the hungry sparrow, or the inquisitive young nature-student. This is the method of hiding by what is usually known as "protective resemblance."

Let us take an instance. In our minds we may picture the brimstone butterfly, the large yellow butterfly that is seen upon the wing rather commonly in late summer, and again in early spring. The under surface of the wings is of a greener tint than the upper; and, if you will look at one of these butterflies with its wings closed, you will agree that it looks not at all unlike a fading leaf. When, therefore, it wishes to retire for the night, by folding its wings, it makes itself as like a dead leaf as possible, and then hangs by its feet below a bramble-leaf, and is safe from its enemies till it is ready to fly again in the sunshine of the following morning.

Our next example may be a large moth. How is this insect able to hide itself so successfully? Take one called the crimson underwing, because it has most gorgeous crimson and black under wings, covered, however, by brown and gray upper wings. Like many moths of the same kind, it sleeps during the day and flies at night. If, therefore, it chose as its sleeping-place a tree-trunk, or some similar grayish-brown surface, it would be very well protected.

Another instance of a similar kind, but not quite so striking, is that of the early gray moth on the trunk of a Scotch fir. The bark of this tree lends itself particularly well to this kind of thing, and many are the animals—not always insects—that make their home, or seek their rest, under its kindly protection. Indeed, an afternoon among the fir-trees will afford boundless delight to the earnest naturalist.

In the buff-tip we have a moth which folds its wings in a peculiar manner when at rest, and changes its appearance most strikingly when it spreads its wings to fly. In its resting position it looks very like a piece of grayish stick broken off roughly at one end—the head—and shaved off cleanly, as if with a knife, at the other end. "When I once found two of them on the bottom of a dried-up ditch," says a naturalist, "I was able to realize how well their peculiar shape and color protect them."

Many moths, especially when their wings are closed, resemble dead leaves. Perhaps the lappet, by the peculiar way in which it arranges its two pairs of wings, does so more closely than any other. It is rich brown in color, like the copper-tinted autumn foliage. Moths among leaves would almost certainly be unnoticed by any one who was not expecting to find them.

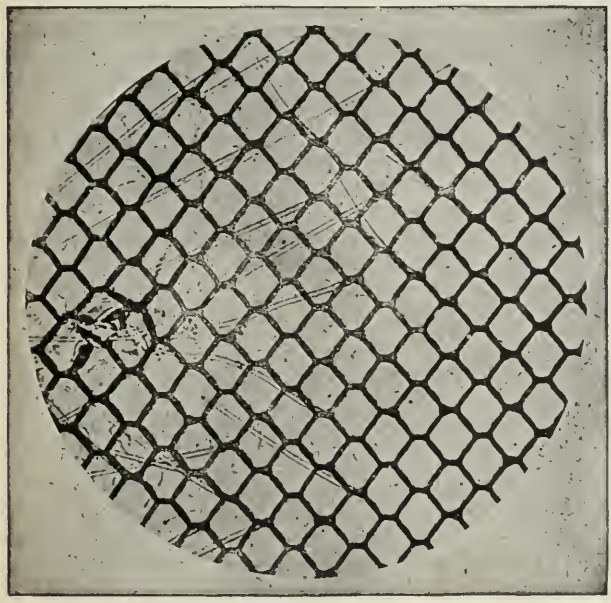
This reminds us of a naturalist who was looking at a brown leaf that had fallen on a living plant. It presently struck him that the leaf was perhaps in reality a moth. This was the case. His eye being now "educated," he shortly found another "moth"—this time it was a leaf!

If you have a chance, study the caterpillar of the peppered moth, which, by its color, folds, and wrinkles, resembles a twig of the branch on which it rests. So true is the resemblance that one has sometimes almost to touch the "twig" to find whether or not it really is what it pretends to be.

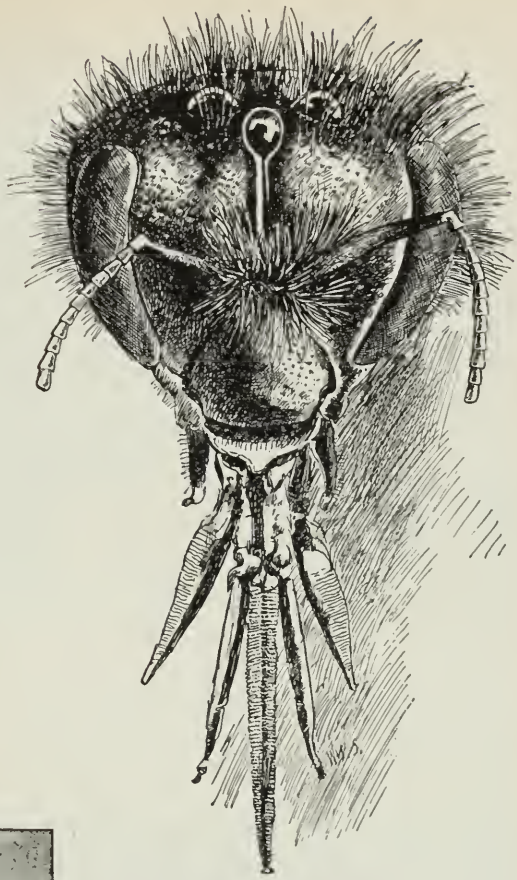
Though our attention has been confined to protection in the case of butterflies and moths, yet equally good instances are to be found all through the insect world; but the cases you have just considered should show you what to look for on your country rambles, and the naturalist with the seeing eye will find instances of protective resemblance around him wherever his walks may lead.

HOW INSECTS SEE

On page 289 we found out about the little whirligig-beetles so often seen even in very cold weather in an open space in brook or pond—"the sprightliest bit of life in all the winter landscape." Its sight is good, being furnished with a queer double set of compound eyes,—one set for seeing upward and the other downward,—for the little beetle spends much of its time darting about on the surface of the water, and must be on the lookout for enemies in the air and in the water.



THE SIX-SIDED FACETS CLEARLY SHOWN IN A GREATLY MAGNIFIED SECTION OF THE COMPOUND EYE OF A FLY THAT GREATLY RESEMBLES A HONEY-BEE.



GREATLY MAGNIFIED VIEW OF FRONT AND TOP OF HEAD OF WORKER HONEY-BEE.

(Shows the large compound eyes,—one on each side of the head,—and the three simple eyes between them on the upper part of the head.)

"But what is a compound eye, and how do this and other insects see?" our thoughtful young observers probably inquired when they read the article.

Nearly all insects have one pair of compound eyes, with which our young folks are familiar as the large, bulging, glistening objects on the sides of the heads. In the dragon-fly, grasshopper, and even the common house-fly, these eyes are very conspicuous. You recognize this organ at once as an eye; but when you come to examine it with a pocket-microscope, or even very carefully without any magnify-

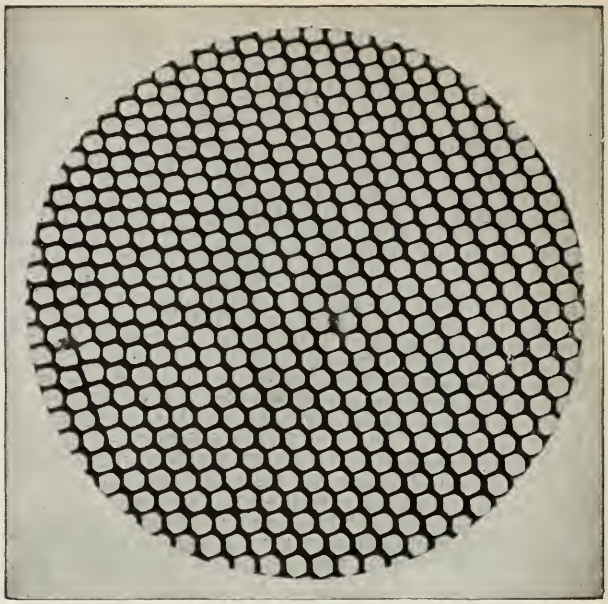
ing aid, you readily see that this eye is very different from that of larger animals. The surface is divided into a large num-

WORKER HONEY-BEE.

A BEE-FLY.

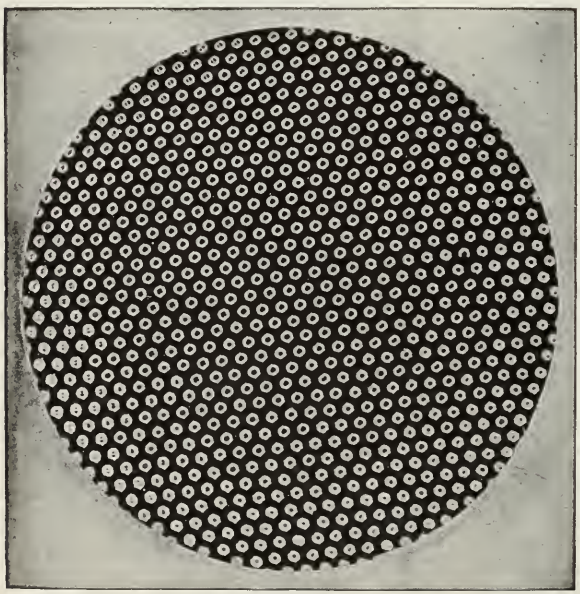
ber of six-sided divisions, called facets. We see that what at first appeared to be a single eye is really an organ composed of hundreds—yes, in many cases even thousands—of eyes, and is therefore called a compound eye.

In addition to this pair of large compound eyes, there are, in many full-grown insects, simple eyes, in number from one to four, between the compound eyes. The most common number is three, so arranged that imaginary lines connecting them would form a triangle. It is supposed by scientific people that "these simple eyes are useful in dark places and for near vision."



SECTION OF THE EYE OF MOURNING HORSE-FLY (*Tabanus atratus*), SOMETIMES CALLED BLACK BREEZE OR GADFLY, GREATLY MAGNIFIED. SIX-SIDED FACETS READILY SEEN.

It is very difficult for us to understand how things appear to an insect with the many parts of the compound eyes pointing in every direction. Just try to imagine yourself flying through a room and seeing the four walls, floor, and ceiling all at the same time and equally well. And yet the insect probably does n't see anything as clearly and as distinctly as we do. Perhaps things are in a blur, as this page would be to you held ten feet away. Or hold both hands in front of you about two feet apart. Look at one and you can see dimly the other—about as clearly as the insect sees everything. Although you do not see clearly the hand at which you are not looking directly, you can tell accurately whether it is in motion or at rest. You can also tell its color. Although the insect sees things vaguely, it likewise can accurately and instantly detect motion and distinguish colors.



GREATLY MAGNIFIED VIEW OF A PART OF THE EYE OF A DYTISCUS.

(This was photographed in a microscope. The light used was from a lamp. The flame shows faintly repeated in the facets. Examine with a reading-glass, and you can see the six-sided divisions between the facets.)

MOURNING HORSE-FLY.

The dragon-fly has very large compound eyes with over twenty-five thousand facets. If you have ever tried to get near one or to

catch it in a net, you doubtless fully agree with scientific grown-up folks that it can see better than any other

A DYTISCUS, OR "DIVING" BEETLE.

of our insects. Even the insects that see so dimly and in a blur are better off than many lower forms of animal life—forms that have no eyes, only a sensitiveness to light and darkness of the same nature as that of plants.

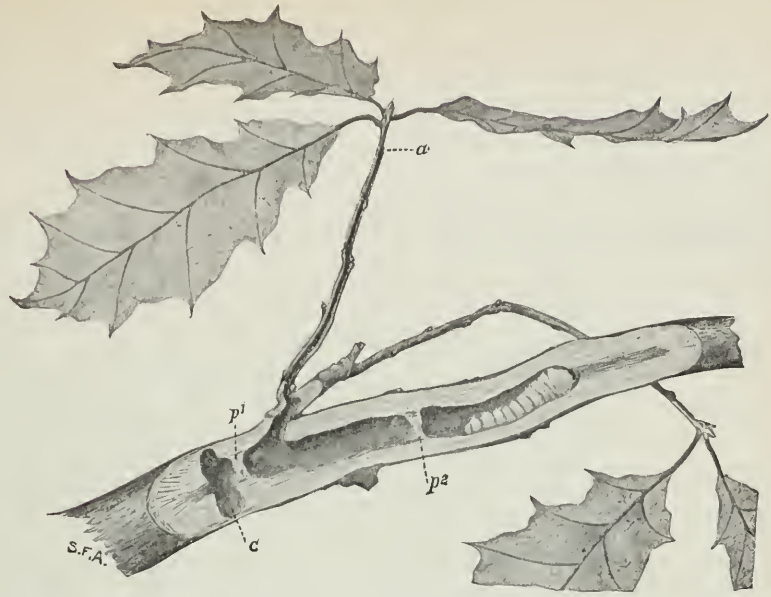


Fig. 2. Red-oak branch and twig, cut open to show the burrow of the oak-pruner larva. *a*, where the egg was deposited; *c*, where the branch was cut nearly off; *p1*, first powder-post plug; *p2*, second plug.

Fig. 1. A branch split open to show the enlarged pupa of the oak-pruner beetle (*Elaphidion villosum*). The beetle is about five eighths of an inch long.

WHEN THE BRANCH BREAKS, THE BABY BEETLE WILL FALL

If, at almost any time of the year, we walk through the woods where the red, scarlet, black, or pin oaks are growing, we shall probably find on the ground fallen branches that vary in size from that of a lead-pencil to that of one's thumb, or even larger. These, at the broken end, appear as if cut away within the wood, so that only a thin portion is left under the bark. Within the rather uneven cut, generally near the center of the growth, is a small hole tightly plugged by the "powder post" of a beetle larva. Split open the branch or twig, when a burrow will be seen, and the little white, soft, hard-jawed larva that made it will be found, or perhaps the inactive pupa, shown in Fig. 1. The beetle, emerging in the spring or early summer, lays its eggs on the soft twigs of the oak, cutting a slit for the purpose, and depositing a single egg on each selected twig. The tiny larva cuts its way into the soft pith until it reaches the larger branch, where it increases its burrow as it increases its size. After the branch is cut, during the autumn the larva withdraws into its burrow, and plugs up the hole at *p1* (Fig. 2), so that no enemy can enter when the limb falls. It then continues to eat its way along the branch, and makes another plug (*p2*), and is now nearly full grown.

IN THE WOODS AND MOUNTAINS

A VISIT TO A COLORADO GLACIER

BY F. H. KELLOGG

In the northern part of Colorado, a spur range of three peaks extends in an easterly direction from the Front Range of the great Continental Divide. This little spur is called the Mummy Range, from a fancied resemblance to an Egyptian mummy reclining at full length. The highest point, Hague's Peak, forms the head, and a somewhat lower summit two miles to the north and west marks the knees of the prostrate figure; the feet extend to the Front Range, where the third peak, Mount Fairchild, raises its gigantic form.

On the northern slope of the second peak there rests an immense mass of snow and ice, which, in the light of recent investigation and discovery, has greatly increased in interest to the mountain-climber and explorer. The very existence of this snow-field is a comparatively new discovery, and until a few years ago the number of visitors to the spot might easily have been counted upon the fingers of one's hands. That this is so is due partly to its isolated and concealed situation, and also to the distance to be traversed and difficulties to be overcome in making the trip.

This mountain, the Mummy, lies twelve or fifteen miles directly north of Long's Peak, in a portion of the country scarcely ever visited, either by neighboring residents or tourists from abroad. The nearest settlement is Estes Park; and from this point the expedition requires three or four days, for great difficulty is experienced in carrying blankets and provisions necessary for so long a stay over the devious and difficult route which affords the only possible means of access to this range.

Upon the occasion of a visit to Estes Park during the summer of 1890, vague reports of the wonderful object on the Mummy came to the ears of a party of several university students, of whom I was one. We were then camping in Willow Cañon. It extends in among the mountains, and it then furnished a site for the last human habitation this side of the Continental Divide. As soon as we heard that an actual glacier was within reach, we at once resolved to see it, and active preparations for the trip were immediately begun.

The history of the discovery of this glacier is an interesting one. An old bear-hunter chanced upon the field on Mummy Mount, which he called "the largest snow-field in the Rockies." Before his death, which occurred shortly after, he mentioned this discovery to a gentleman then living in Denver, who devoted much time to the exploration of new mountains and strange localities in and about this neighborhood.

In 1882 this gentleman, a Mr. Hallett, visited the spot entirely alone. In trying to ascend the north side of the ice-field, he suddenly broke through the bridge of a hidden crevasse; but by extending his elbows, he managed to extricate himself from his perilous position and returned in safety to his camp. This incident finally led him to wonder whether this might not be a glacier. In 1886 and 1887, Mr. Hallett, in company with an experienced mountaineer who was as familiar with the Alps as with the Rockies, twice revisited the spot. Upon the first of these expeditions, after a careful examination, the true nature of this vast expanse of snow and ice was, for the first time, positively determined. Here, in the heart of Colorado, existed a true glacier showing crevasses, moraines*—in short, all the characteristics of the well-known Alpine glaciers of Switzerland. To this was given the name it now bears, "Hallett Glacier," in honor of the

* A moraine is an accumulation of sand, broken stones, and rocks along the edge of a glacier.

man who, in such a startling way, made the first real discovery.

We had no guides and few directions: but we could, from a distance, distinguish at least the Mummy from the surrounding mountains, and we trusted in our ability to find some way, unhampered as we were by any great amount of luggage.

Just before leaving Estes Park we halted at a ranch for a final adjustment of "Billy-the-Burro's" pack and a general making ready for the climb, now just ahead. On the way we encountered an old mountain stage-driver, grizzled and weather-beaten, who seemed much interested in our party. After carefully inspecting our various equipments, he asked: "Whar mought ye be a-goin'?" One of us replied: "To the Mummy. Ever been there?" "Bin thar? Bin thar? W'y, looky here, young chap; I 've bin thar when you did n't hev no more sense 'n a tarmidgun [ptarmigan]. But yer better take an ol' man's advice an' stay ter hum; fer ye 'll never git back ag'in—nobody ever has. Take my advice, and let ol' Mummy alone."

We wondered how *he* got out alive, but we refrained from questioning him further.

Undaunted by this terrible warning, we trudged gaily along, and, leaving Estes Park, entered Black Cañon, carefully noting, for possible guidance on our return, peculiarities along the route as we traveled.

Soon we were completely enveloped in the mysterious shades of an immense forest. Pushing steadily on, we arrived, at about dusk, at the base of a peak which we thought to be our destination, the Mummy. We halted here for the night, and pitched our camp, which process consisted merely in throwing off our packs and starting a fire. A threatening storm induced us to gather a great pile of logs near the fire, in order that a rain might not deprive us of this the one great solace of a night in the open. We had barely finished our supper when the storm broke upon us, cold rain and sleet, for at that elevation, of about ten thousand feet, it was cold, and there was snow on the mountain peak above.

THE HALLETT GLACIER—NEAR VIEW.

At this height the small scrubby trees afforded but little protection against the rain, so we wrapped ourselves in rubber blankets and, with feet to the fire, lay down to sleep.

Early the next morning all was bustle and activity. As we prepared our breakfast of ptarmigan and coffee, eked out with cold supplies, the clouds rapidly disappeared, and the first rays of sunlight tinged the peaks and forests with a delicate pink. Delighted with this favoring weather, we started again on our search for the glacier. We made rapid progress, and in a few hours stood just at the foot of the topmost cap of the huge mountain under whose shaggy mane of spruce we had encamped for the night.

We rounded the cap, expecting, as we reached the north side, to come upon the glacier. Instead we saw nothing but great rocks strewn everywhere upon the bald top of the mountain. Ahead for several miles we saw a deep chasm, presenting the only possible location for a snowfield of great size.

This chasm, within whose inclosing walls might be concealed the object of our search, really cut into the mountain lying next to the west; and this, we thought, could not be the Mummy. We were, therefore, undecided as to our course. By this time it was late in the afternoon, so we divided

our party into two sections and started off in slightly differing directions; but the day was now too far gone, so we were soon obliged to return to camp without being rewarded in our search.

The next morning we made a long detour around the side of Hague's Peak, avoiding the most difficult climbing, and soon found ourselves within the former pathway of the glacier, an immense chasm strewn with rocks piled on rocks for miles and miles, a most wild and desolate scene. From this point, however, we could see the upper snows of the great mass, and, greatly encouraged, plodded on. After some two hours' scrambling over rocks, we neared an immense rocky ridge or dike extending across the gorge, which we rightly took to be the terminal moraine of the glacier lying above.

I ran, jumped, and fell in a wild scramble over the irregular piles of rocks, my camera bouncing and bumping on my back and shoulders. After a distance of about a half-mile was thus traversed, I climbed the dike, and the whole mass was in sight. Before pausing to really admire the grandeur of the scene before me, I adjusted my camera and made five quick exposures. In a few moments the clouds came twisting and curling in at the head of the gorge; then, settling down, the whole view was obscured in a dense sea of mist and fog.

An immense snow-field, about a quarter of a mile in width, extended to the top of the mountain, a thousand feet above. Its whole extent was covered with grooves, markings, and cracks. A little lake, formed by the melting of the snow and ice above, nestled at the foot of the ice-field, its waters imprisoned by the great dike. This lake was partially frozen over, and in the occasional open spaces large blocks of ice were floating round. Moved by the force of the wind, they grounded upon rocks or firmer ice underneath, then were lifted up with a groaning and creaking, varied by sudden splashes, as large fragments broke off and fell into the water. The lower edge of the ice and snow projected over the water, rounded off in beautiful combings and rolls, apparently about to drop off into the lake. Even as we looked, our attention was attracted by a sharp crack, followed for a few seconds by a continuous crackling sound; then, with a loud report, an immense block of ice broke off and fell into the water with a great splash, showing us in miniature the process by which great floating icebergs of the arctic seas are formed.

Our visit was made during the month of Au-

HALLETT GLACIER FROM ACROSS THE LAKE.

gust, yet the whole surface of the glacier was covered with snow. Situated far up there, at an elevation of almost fourteen thousand feet, and sheltered from the sun and wind by the high walls of its inclosing amphitheater, only a very little actual melting occurs—just enough firmly to pack the snow upon the ice, and so prevent its breaking up.

The possible presence of other, smaller crevasses, hidden under a thin bridge of snow, suggested extreme caution in our movements. However, we determined to attempt the ascent of the icy slope to the rocky ridge above. After numerous slips and falls, and narrow escapes from sliding into the lake, but luckily with no serious mishap, we reached the jagged cliff extending above the mass.

Encouraged by our success, we followed the crest of the ridge around the head of the glacier; then a short but steep climb brought us to the topmost cap of the Mummy.

When the top was reached, we were amply repaid for our labor and pains. From this vantage-ground is obtained a view probably unsurpassed in all Colorado; for this peak is about fourteen thousand feet above the sea-level, and stands out on a spur from the Great Divide, thus affording a reach of vision much more extensive than from some of the higher peaks of the divide itself.

In the east appeared the plains of Larimer County, dotted with lakes, sparkling gems in an emerald setting, a view pleasing and restful to the eyes. Farther toward the south, a dark blotch of smoke marked the location of the smelters in Denver. To the south, Long's Peak presented the only obstruction to our gaze in that direction; while in the west the Park and Medicine Bow ranges of snow-clad mountains showed something of the magnitude and extent of the great Rocky system. To the north stretched away the plains of Wyoming, bounded in the distance by great white mountains. Immediately at our feet we looked down upon the glacier, the sun's rays glistening upon the ridges and blocks of ice and refracted in a dozen different colors.

So extensive and apparently limitless was the view that our eyes finally became weary with gazing, and we determined to return home.

Frequently losing our way, then recovering it, we went on by day and night, until, on the second day, we reached a clearer field; then we pushed along at a rapid pace, and at about 10 P.M. arrived at our cabin in Willow Cañon, cold, wet, tired, and hungry, but full of praises of the view from the Mummy, and of the only known glacier in the interior of our continent.

HONEY-HUNTERS

Poor little bee! It spends its days in gathering nectar from the flowers to make into honey,—just to have some bigger and stronger creature come along and rob it of the fruits of its hard labor.

It is not only man who has a sweet tooth; a great many other animals are just as fond of honey as is he, and will do almost anything to obtain it; that is, anything but work for it. For I very much doubt if so much honey would be eaten if those who like it had to make it, even supposing that they knew how to make it.

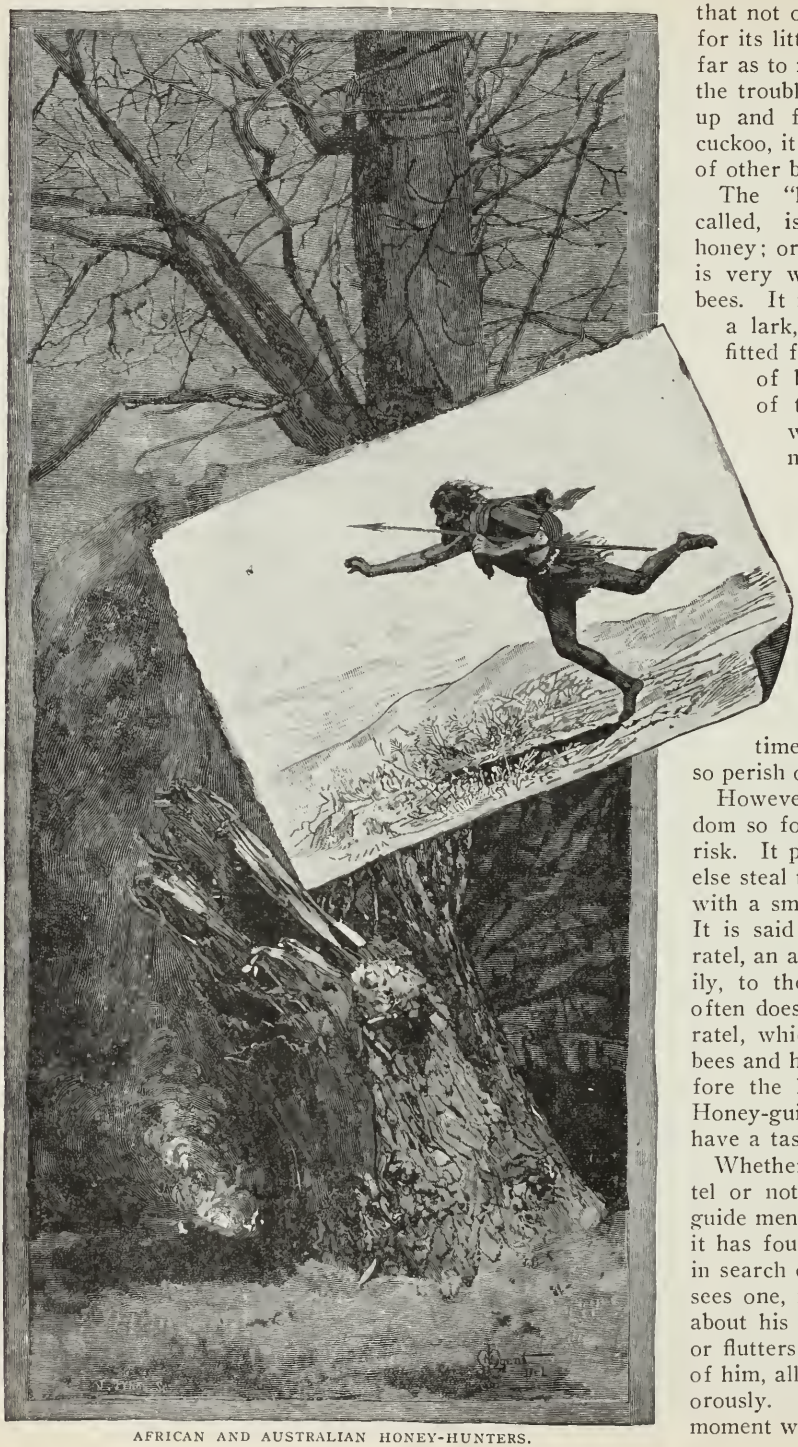
Just think of it! Honey is chiefly sugar, and the nectar from over three million flower-tubes is required to make one pound of sugar. Or, suppose one very industrious little bee should decide to make enough honey to contain a pound of sugar. It would have to sip the nectar from fifty thousand heads of clover in order to obtain the necessary quantity.

And yet after a bee colony has taken an immense amount of trouble to lay away a goodly supply of sweets for the little bees, a great bear, perhaps, will thrust his shaggy paw into the nest and pull out layer after layer of the white comb, dripping with thick golden honey, and swallow them down, like the gluttonous fellow that he is. And in return the poor bees can only sting, which can not be any real satisfaction to them; for though they may hurt the creature stung, they end their own lives in the act.

In a great many countries, bees are kept for their honey, just as cows are kept for their milk, and are well cared for; but where people are too lazy or too savage to keep bees, it is usually the custom to steal honey from the wild bees and often to kill most of the poor little creatures at the same time. Usually, however, the bees are stupefied by the smoke, so that they will not sting while the honey is being removed.

Generally, wild honey-bees build their nests in the hollows of trees, but there is a species in India that builds great nests hanging from the branches of high trees. Some of these nests are so large that they can be seen more than a mile away. Of course such a nest has quantities of honey in it. Some of the natives of that part of the world live the whole year long upon the proceeds of honey stolen from these hanging hives. When a man discovers a nest, he provides himself with a smoking torch and climbs the tree. He stupefies some of the bees, suffocates others, and burns the rest. Then he steals the honey-laden comb and lowers it by means of a cord to the ground.

In Africa the bees have a very hard time; for there man has a sharp-eyed, active little friend to help him find the carefully hidden honey. This little friend is a bird,—a rascally, shiftless fellow, that not only fails to build a home for its little ones, but even goes so far as to make other birds have all the trouble and worry of bringing up and feeding them. Like the cuckoo, it puts its eggs in the nests of other birds.



AFRICAN AND AUSTRALIAN HONEY-HUNTERS.

The "honey-guide," as it is called, is exceedingly fond of honey; or, if it can not have that, is very well satisfied with young bees. It is only about the size of a lark, and so is not specially fitted for encountering a swarm of bees fighting in defense of their home. Once in a while, it tries to rob a nest, but it is usually well punished for doing so. The little bees seem to know that their stings can not injure the feather-covered body of the bird, and accordingly they direct their attacks at the eyes of the robber; and if the bird does not escape in time, it will be blinded, and so perish of starvation.

However, the honey-guide is seldom so foolish as to run any such risk. It prefers to have some one else steal the honey, and is content with a small portion for its share. It is said sometimes to guide the ratel, an animal of the weasel family, to the nest; and it certainly often does wait near by, while the ratel, which is very fond of both bees and honey, rifles the nest. Before the honey is all gone, little Honey-guide usually contrives to have a taste.

Whether the bird guides the ratel or not, it unquestionably does guide men to the bees' nests. When it has found a nest, it darts away in search of a man. As soon as it sees one, it hovers over him, flies about his head, perches near him, or flutters here and there in front of him, all the time chattering vigorously. The native knows in a moment what the little bird means;

and as he loves honey as a child does candy, only something that is very important will prevent his accepting the honey-guide's invitation. When he is ready to follow, he whistles; and the bird seems to understand the signal, for it at once flies on for a short distance and waits till the man is near, and then flies on a few yards farther. In this way the bird leads the man until the nest is reached. Then it suddenly changes its twitter for a peculiar note, and either hovers over the nest for a moment, or complacently sits down and lets the man find the nest as best he can.

When it is found, the bees are smoked out with a torch or with a fire of leaves, according to the height of the nest from the ground. A small portion of the honey is given to the bird as its share of the plunder. If the little fellow has had honey enough, it disappears; but if, as is usually the case, it receives only enough to whet its appetite, it will lead to another nest, and sometimes even to a third.

Once in a while, a man who is running after the little bird finds himself suddenly face to face with a wild beast or serpent. This is likely enough in a country that is so well supplied with both. But the natives say that the honey-guide is naturally wicked, and that it sometimes leads unsuspecting men into traps for the mere pleasure of villainy. Careful observers, however, maintain that this is not true.

In Australia, where there is no little bird to find honey for him, the native adopts a very peculiar plan for discovering the hidden sweets. He knows that bees never wander very far from home, seldom more than two miles; and he also knows that when a bee is laden with honey it makes, as nearly as possible, a straight line for home. All that is necessary, then, is to find a bee that is well laden and follow it. But that is more easily said than done; for although it is quite easy to determine whether the bee has a full cargo, it is difficult to follow it. Any boy who has tried to follow the big and gay-colored bumble-bee to its nest knows how great a task it is. But that is a mere trifle to following the sober little honey-bee, which can be lost, like a dream, against a gray-colored hillside. Moreover, a half-dozen other bees may cross its path, and then you can imagine how difficult it would become to distinguish the homeward-bound bee from the others. That sort of a wild-bee chase would be little better than the traditional wild-goose chase.

In order to be followed, the bee must have a distinguishing mark that can be easily seen, and with such a badge the Australian provides it. He simply gums a small tuft of white cotton to the bee's back, and is thus enabled to follow it with comparative ease. A bee carrying a load of honey, and with a miniature bale of cotton on its back, can not fly very swiftly.

But the question now comes up, how is the cotton to be put upon the bee's back? The gum is quickly found—it is on almost any tree; the cotton grows right at hand. The bee, too, is found in almost any sweet flower, buried head first in the dusty pollen, drinking in the nectar and showing quite plainly whether its honey-sac is full or empty. It moves a little in its eager haste to secure the delicious liquid, but perhaps a quick dab will fasten the cotton on its back.—Do not try it. As the little boy told his mother, the bee is a very "quick kicker."

Watch the Australian,—and he a very stupid fellow, too, in most things. He fills his mouth with water, has his snowy tuft of cotton ready gummed, finds his bee, gently drenches it with water spurted from his mouth, picks it up while it is still indignantly shaking itself free from the water which clogs its wings, and with a dexterous touch he affixes in an instant the tell-tale cotton.

Very much out of patience, no doubt, with the sudden and unexpected rain-storm, the bee rubs off the tiny drops from its wings, tries them, rubs again, and soon—buzz! buzz! away it goes, unconsciously leading destruction and pillage to its happy home; for a few yards behind it runs the honey-hungry savage, his vigilant eye fixed on the moving white speck which is to carry him to so sweet a destination.

We, who use millions of pounds of sugar and hundreds of thousands of pounds of honey every year, need not be surprised that the savage, who has only honey for sweetness, should be eager to use every effort to obtain it. The human family doubtless needs a great deal of sweetening, for vast quantities of honey and sugar are used all over the world.

In ancient times honey was almost the only sweetening substance used, and it was consequently very highly valued. The promised land was described to the Israelites as flowing with milk and honey, and that, to them, was as much as a land full of gold to the men of these times. And it was not merely what is called "a figure of speech" to say that Palestine flowed with milk and honey, for where cows thrive, bees thrive; and to this day there is no part of the world where honey is so plentiful as in Palestine.

In Judea, particularly, there are so many wild bees, that many of the inhabitants gain a livelihood simply by gathering honey from the crevices in rocks and hollows in trees. One traveler says that the trees in the forests in the Holy

Land do, in truth, "flow" with honey, for the fat combs full of it hang from the trees on every hand.

Honey is good, but it is not safe to eat every kind of honey you may chance to find; for honey made from poisonous flowers is usually poisonous also. This poisonous honey is found in all parts of the world, and accordingly, when you find a nest of wild bees, look carefully about and see if there are many poisonous flowers growing in the neighborhood. If so, be resolute, and abstain from eating the honey. For thus you will be good to yourself and to the hard-working bees as well.

JOHN R. CORYELL

IN THE WOODS—APRIL

So much of April has to be taken up with rain and clouds that on a chilly, drizzling day we are apt to forget the hours of sweet, hot sunshine that are taking turns with the rain to melt the frost out of our hills and woods. But the moment the rain is over, or before,—a vigorous boy or girl is not going to be hurt by an April shower,—let us go out and look for the first spring flowers.

As far as I have seen, the race for first place in the spring pageant of flowers results in a tie. If you find a Mayflower just peeping open on the edge of a wood, you are pretty sure to see a nodding blue hepatica on the same day. The time of year varies, of course, as you go farther north, and with the particular season; but it is a good plan to be on the lookout for these two flowers, the leaders of the procession, as early as the first warm days in April.

The Mayflower (*Epigæa repens*), also called trailing arbutus and ground-laurel, belongs to the heath family, of which the rhododendron, the blueberry, and the English heather also are members. Every one knows its lovely, shell-like pink-and-white flowers, and its delicate fragrance, the first and most exquisite breath of the spring.

It is a little trailing plant with a tough, rusty stem and heart-shaped leaves very thickly netted, of a rather dull light green. The flowers grow in clusters. They are gamopetalous; that is, instead of having five petals, as one would think, there is really but one petal—a slender tube opening out into five points. They vary from pure white to a deep rose-pink.

Look first along the southern edge of a wood, on some bank or hillside facing the sun and sheltered from all the cold north winds. You will be pretty sure at last to see a little white star, and then a cluster of pink buds.

A few days later you will find them blossoming thickly through the places that they like best of all—fields of dead, dry grass, and brown hummocky pastures. Here you will probably find the pinkest ones, usually one plant by itself that for some reason has deep-rose colored flowers, while all its neighbors are in apple-blossom pink and white. The dark-pink Mayflowers are much prized, but they are hardly more beautiful than the pure white ones, which blossom deep in the woods long after their sisters in the fields have withered. These Mayflowers growing in the woods have a character of their own: the plant is usually thin and straggling, not compact like those in the open field; the leaves are large and very green, and the large white flowers are apt to come singly instead of in thick clusters.

But, wherever you try to find Mayflowers, you must know how to look for them. When you see a flower, follow the stem carefully, and you will find that it brings up with it half a dozen pink clusters that were wholly hidden. Only sometimes after a warm spring rain the little flowers seem to come out to drink, and where the day before you could scarcely find one you will see hundreds.

And a word about how to pick them. The stems are very tough. You try to break them,

THE TRAILING ARBUTUS.

EASTER LILY

HOLLYHOCKS

then to twist them; then you give a pull, and up the whole thing comes. Take two good things with you on your spring walks—patience and a penknife; and don't, because you like Mayflowers, destroy the little plants that might give so much pleasure to you and to other people year after year.

As I said, the hepatica (*Hepatica triloba,* crowfoot family) blossoms at the same time as the Mayflower. It is a beautiful little six-petaled flower (botanically speaking, what appear to be petals are really *sepals,* that is, divisions of the calyx, the hepatica having no *true* petals) set on a slim, graceful stem. It varies very much in color (the buds are of a deeper tint than the open blossoms) from white to purple and purplish pink, and sometimes to pure blue. The leaves are evergreen, and are beautifully shaped, cut in three deep, regular lobes; the stem, buds, and calyx are covered with a gray silky down.

The hepatica grows in little separate clumps of many blossoms each, like violets. It is as common as the Mayflower, but you will never find it in such quantities. Look for it through rather open woods and in small clearings, or up the steep side of some gravelly hill, where you will see it nodding among the stones and bushes. It is of no use to pick it: the little flowers will droop before they have been ten minutes in your warm fingers.

THE HEPATICA.

Our next flower, the early saxifrage (*Saxifraga Virginiensis,* saxifrage family), is not quite so common, though still not at all hard to find. As its name—coming from the Latin words *saxum,* a stone, and *frango,* to break—suggests, it is fond of growing in the clefts of rocks. I have found it on the surface of a boulder where there seemed at first no crevice at all, no chance for the little roots to get nourishment. The botanical direction for finding it is, "exposed rocks and dry hillsides." You might hunt along a good many dry hillsides without seeing it, or you might pass it many times without noticing it, as it is rather a modest flower; but sooner or later you are sure to come across one, looking like a bit of white fringe seen against the rock.

The saxifrage seems to show that it is used to scanty fare, and to holding its own in hard and dry places. It is a straggling little plant, with hairy, rather clumsy, branching stems, and small, very thick, not easily seen leaves clustered at the root, the whole plant seldom growing more than five or six inches high. The small white flowers (sometimes a grayish white) have five petals, and grow in pretty little clusters, very close at first, and spreading out and becoming more feathery as the flowers open.

At this same time of year, though not quite so early as the first hepaticas and Mayflowers, you will find, in rather damp places on the side of a

gully, or on a wooded bank by some brooklet, the dog's-tooth violet (*Erythronium Americanum,* lily family). It is an exceedingly "local" flower; that is, you may find a patch in a particular wood, and not again within a circle of, say, ten miles; but where you do find it you will see it covering the side of a whole valley and nodding with almost countless yellow flowers. Where it got its name it is hard to see; it resembles a locomotive quite as much as it does a dog's tooth, and it is in no sense a violet. In fact, if you turn back the flower and look into it, you will see that it is a most perfect little lily. The curving yellow petals, the shape and poise of the flower, show at once that it is a cousin of the stately Canada lily, that blossoms in July, and of our garden lilies.

The flowers grow singly on slender stems, the plants growing close together, not in separate clumps or patches, but covering the ground as with a carpet. The most striking thing about the plant is its leaf—a large, rather thick leaf, mottled with brown or purplish spots.

THE SAXIFRAGE.

And now, by the time the dog's-tooth violets are in full blossom, you no longer have to hunt so carefully for your wild flowers. The brown fields where the Mayflowers opened are turning green, the woods are springing with undergrowth, and on every side little buds are opening white petals spreading to the sun, fuller and richer every day as the spring comes on.

ROSALIND RICHARDS.

THE DOG'S-TOOTH VIOLET.

THE WOODS IN EARLY SPRINGTIME.

IN THE WOODS— THE FLOWERS OF MAY

THE ANEMONE.

May and June are the royal months for wild flowers. There are no such showy masses of color as come in July with the daisies, or in August with the goldenrod, but all the wonderful lower world of the woods, which later sobers down to the cool summer greenness, is twinkling with countless delicate flowers, and flowering trees—shadbush and cherry and hawthorn—are breaking into blossom overhead.

Most of these beautiful little wild flowers can be easily distinguished by striking color or shape—the violets, purple or yellow, the rose-pink fringed polygala (sometimes given the name "lady's-slipper," to which it has not the smallest resemblance); but there are five or six small white flowers, blossoming at about the same time, that are enough alike to be often mistaken for one another, though when you once know and love them you will never confuse them. Last spring a little girl—quite a big little girl—asked me to tell her the name of "that little starry white thing that grows in the woods." Going out to look for it, I found she was not quite sure which of four flowers she meant.

TRIENTALIS AMERICANA.

The best known of these small white blossoms is the anemone (*Anemone nemorosa,* crow-foot family), which nearly every child has seen and picked. The plant, which grows for the most part in open pastures, forming little colonies about old stumps and sunken boulders, is from four to six inches high. It has a straight, slender stem, crowned with a whorl of three very smooth, trifoliate (that is, having three separate leaflets), deeply notched leaves, from the middle of which springs the still more slender flower-stem. Each plant has one flower. The small, tightly closed buds vary in color from purple and pink to blue, which fades as the flower opens. They hang their heads very low, hiding the mass of stamens in the middle, until they open fully, when they stand erect, pure white, five-pointed stars.

The star-flower, perhaps the most beautiful of these delicate

DWARF GINSENG.

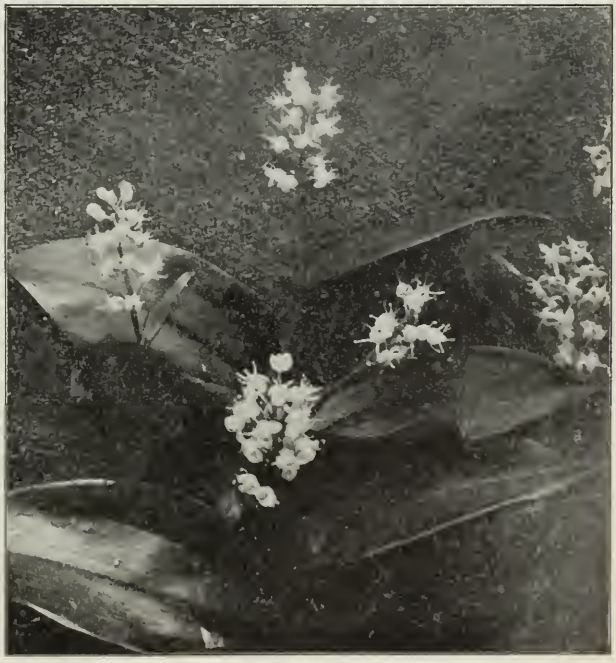
white wood flowers (*Tricntalis Americana,* heath family), is somewhat like the anemone in growth, but it has a whorl of many leaves instead of only three, and the leaves are uncut, pointed, and of a beautiful warm light green. Sometimes you will find three flowers to a plant, sometimes only one, but the common number is two—twin white stars. The blossoms, like those of the anemone, spring from the center of the whorl of leaves, on stems as slender as a thread; they are white as snow, with delicately pointed petals and tiny yellow or orange anthers setting off the whiteness.

Still another plant grows in much the same way as the anemone, though, like the star-flower, it is of an entirely different family. This is the dwarf ginseng or groundnut (*Aralia trifolia,* ginseng family). It has the same whorl of three leaves, each leaf having three, sometimes five, leaflets; but the leaflets are only notched, not deeply cut, like those of the anemone, and they are of quite a dark green. The many small feathery flowers are clustered together into a head—an umbel, as it is properly called. Most of the ginseng family have spicy, aromatic roots. Those of one variety are used by the Chinese to mix with opium, and so they bring a large price.

The dwarf ginseng and the star-flower both like the deep woods, though they are also found in open pastures. They do not grow in close groups, but are scattered freely through the forest, springing up between the dead leaves; only, the star-flower likes a rather dry, open wood, a young beech-growth for instance, while the ginseng chooses moister places.

The little goldthread (*Coptis trifolia,* crow-foot family, the English name coming from the bright yellow, thread-like roots) is so small, so fine and delicate in growth, and so near the ground, that without looking closely you will scarcely notice it. The whole tiny plant (it is only four inches high) seems to shine; the petals look as if polished; the stamens are like spun glass. The leaves shine; they have three rounded leaflets, notched along the edge, with slender, juicy stems, looking somewhat like young celery plants in the garden. The plant is evergreen, and you can find the bright-green leaves under the snow.

The maianthemum (*Maianthemum Canadense,* lily family) takes us back to the open pastures, where it grows in close colonies through the sweet-fern, and about old stumps and ant-hills. It is a small plant, about five inches high. The creamy white flowers grow in a sort of close



MAIANTHEMUM.

FALSE MITERWORT.

GOLDTHREAD.

spike or raceme; the leaves are broad and shining, of a beautiful warm green. It is pretty stiff in growth, but this is made up for by its lovely contrast of color. I do not know any English name for the maianthemum, though it is sometimes mistakenly called wild lily-of-the-valley from its broad, smooth leaves.

False miterwort is too clumsy a name for almost the most delicate of all the spring flowers. It seems better to keep to the Latin, *Tiarella*—as pretty a name as could well be found (*Tiarella cordifolia,* saxifrage family). This flower you will find in rich woods, or sometimes by the roadside where there has been a trickle of water. It often grows as high as ten inches, though usually not more than six. The leaves, a light, warm green, are very soft and downy, shaped a little like those of the white maple, and the stems have soft white hairs. The flowers are pure white, with ten long, slender stamens, and bright yellow or orange anthers, growing in an open raceme. Anything more graceful, more feathery and delicate, it would be impossible to imagine; it is as if the fairies' breath had crystallized of a moonlight night.

All through May the wild flowers are almost countless, each more lovely than the last, and your walks through the woods cannot help being a delight. Here is a suggestion. If you know some one who cares for wild flowers, and is not able to go hunting for them in the woods, bring home with you a quantity of tiarella and of that beautiful little straw-colored lily, *Clintonia borealis,* and arrange them—not too many for the size of the bowl—lightly together in a finger-bowl. You will find that no tropical display of orchids can be more beautiful than these delicate, every-day flowers, to be found not far from your own home, in the May-time.

ROSALIND RICHARDS.

IN THE WOODS—JUNE

ONE's first idea of orchids is apt to be of brilliant, fantastic flowers—some of them so strange in shape as scarcely to seem flowers at all—blossoming in tropical forests or under glass in greenhouses. We go to see "orchid shows" at horticultural exhibitions, and often forget that there is an orchid show, even in our very Northern woods, ready and waiting for us every spring. All of our native orchids are beautiful, some of them very wonderfully and delicately so; but we have only a few that are as large or as brilliant in color as those of warmer countries, and of these the "lady's-slippers," or moccasin-flowers, are the most striking. We have several of this family, the splendid *Cypripedium spectabile,* purple, pink, and white, the yellow lady's-slipper, and others—six in all; but through New England, at least, the best known is the pink, or stemless,

LILAC

LILY-OF-THE-VALLEY

STEMLESS LADY'S-SLIPPER.

lady's-slipper (*Cypripedium acaule,* orchis family).

It would be hard to find anything pleasanter than hunting for lady's-slippers on a bright June day. Like most orchids, they are very local in their habits; but when once you know the right kind of place to look, you are nearly sure to find them. The botanical direction is "dry or moist woods, under evergreens," but I have happened to come across them more often under lighter growth—maples or young beeches. Look through light, open woods, and along wooded ridges, where the rock crops out and gray moss crunches under your feet. Sooner or later you will find the lovely things, standing sometimes singly, sometimes in groups of three or four to ten or twelve. The whole plant is beautiful. The great broad leaves are a warm green, and between them, as from a sheath, the downy stem rises, with the perfect blossom bending at the top. The flowers vary greatly in color, from deep rose-pink with purple veinings to palest rose-color; and sometimes, if you are lucky, you will find one that is pure white.

The whole family of orchids has a very curious and interesting peculiarity. Probably you all know that a flower cannot bear seed or fruit unless the fine powder from the stamens, called pollen, falls upon the pistil. In many flowers this happens of itself, but the orchids have to depend upon bees or other insects, climbing in for honey, brushing against the pollen masses, then rubbing off their dusty jackets against the pistil.

Our next flower is hardly less beautiful—the "painted trillium" (*Trillium erythrocarpum,* lily family). You will find it in the latter part of May, as well as in June, sometimes in the same places where the lady's-slippers grow, but generally in darker, richer woods, where the leaf-mold is deep and moist. Sometimes you will find only a single plant; but often there are a good many growing near together, scattered in open ranks among the trees. The plant is usually eight or ten inches high, a single stem crowned with a whorl of three leaves, from the center of which the flower-stem rises. They are all in threes—leaves, petals, sepals; hence the Latin name *Trillium,* and an English name occasionally heard, trinity-flower. The single blossom is bright, pure white, with a crimson stain at the base of each petal.

We have many trilliums: the broad-petaled red trillium, with its unpleasant smell, the great white trillium, or wake-robin, and others, but none so beautiful as this smaller flower, with its crimson painting.

PAINTED TRILLIUM.

And now you must put on your rubber boots, or, better still, take a flat-bottomed boat and a stout pole, for we are going into wet places. There are many enchanting things in plain sight

ARETHUSA BULBOSA.

in a good peat-bog—rhodora, sundew, and, if there are good stretches of open water, water-lilies; but in among the tall tufted grasses that fringe the swamp there hides a delicate rose-pink flower, growing on a tall, slender stem, its roots, like those of the grass around it, actually in the black bog-water—arethusa, another orchid (*Arethusa bulbosa*, orchis family), as lovely and fragile a thing as ever grew in any tropic forest. The leaf scarcely shows, but the stem, with its sheaths, is pale green; the bearded lip has purple markings, otherwise the whole flower is the same pale rose-color.

It is often a difficult piece of work to reach the arethusas, and you must remember that bog-grasses are very treacherous. Some arethusas you can pick by wading in from the shore, some by shoving the boat as far as you can into the grasses; but there will always be many more that you will never even see, waving by themselves when the wind bends down the grasses; and of course it is not in every peat-bog that you will find arethusas at all.

Another bog-flower! Alas for your shoes and stockings! But this plant, buck-bean (*Menyanthes trifoliata*, gentian family), does not hide itself away among the grasses, but fills entire swamps, and you can pick it from the edge. It is an extraordinary flower. The five pointed petals, pure white, though tipped in the bud with pink, are thickly bearded with a white, curling fringe—not down or wool, but a thick, curling beard. The stamens in this curly mass are crimson, and there is just a touch of yellow. The whole plant is about a foot high.

The buck-bean has a wide range, from New England south to Pennsylvania and westward as far as Wisconsin; but it is an extremely local flower. You may know many swamps that *ought* to be exactly the right place for it, and yet never come across it. When you *do* find it, though, there can be no mistake. It fills the swamp from end to end, so that you can see it showing white from a great distance and you can pick it by the armful.

ROSALIND RICHARDS.

BUCK-BEAN.

POLYGALA SANGUINEA.

IN THE WOODS—JULY

Forest wild flowers, for the most part, blossom in the spring months. A walk through the July woods will show us many kinds of fruit beautiful to look at (but this is a case of "handsome is as handsome does n't," some of the pretty things being quite poisonous): the blue clintonia and cucumber-root berries, the handsome white baneberries, like painted china, and the bright-scarlet berries of the dwarf cornel and Jack-in-the-pulpit. We shall see wonders of fern-tracery, but few flowers compared to the myriads that carpeted the forest in May and June. We must go instead to open places, to fields and swamps, to pasture borders, and, first of all, to the roadside. Here is elder in creamy masses, swarming with butterflies; wild carrot, delicate in design as the finest lace; and the tall host of the composite family, daisies, thistles, rudbeckia, hankweed, wild sunflower, and a throng of others, loving the sun, and crowding the open places in bright-colored masses. There are smaller plants also—harebells blowing on rocks and ledges, and the glorious red of the cardinal-flower along the borders of brooks and streams.

Sometimes it happens that by midsummer people have ceased to care so much for studying wild flowers. The delight of being in the woods again after the long winter, and the shyness with which the spring flowers hide themselves away through the forest, keep them interested through the spring months; but by July it is hot, and there are other things to do. Wild flowers are blossoming everywhere in such profusion that they do not seem any longer rare and precious, and too often one hears half a dozen beautiful varieties classed together as "weeds." For instance, last July I came upon a quantity of little flowers, making a mass of pink among the grass, that were quite new to me. I was walking with a lady who had been keenly interested in lady's-slippers in May. "Oh," she said, on my pointing to the flowers, "that grows all about here. It must be some kind of pink clover thing. I have never troubled to pick it."

The "pink clover thing" was *Polygala sanguinea* (it is too pretty not to have an English name, but I have never heard one). A glance at the straight alternate leaves shows that it could be no possible relation of the clover; in fact, it is a sister of the bright-fringed polygala of the spring woods. It is a small plant, six to

POGONIA OPHIOGLOSSOIDES.

CALOPOGON PULCHELLUS.

eight inches high, with a tough, much-branching fibrous stem, and narrow dull-green alternate leaves. The flowerets grow massed together in a head, as close as a head of clover, though very differently shaped. Each plant bears a great many of these heads of flowers, which are bright rose-purple, making beautiful spaces of color wherever many of the plants grow together.

July is a great month for orchids. The earlier lady's-slippers are past, but the splendid showy lady's-slipper is still in blossom, and the delicate-fringed orchises, the white, the purple, the yellow, and the ragged-fringed; and now, too, we find two beautiful rose-pink orchids, so much like each other, and like arethusa, which blossoms in June, that the three are often confused. All three have much the same general characteristics of shape and color, and all three grow in swamps, or at least in swampy places, bogs where the sphagnum moss is thick and wet and velvety.

The most striking of the three is calopogon (*Calopogon pulchellus,* orchis family), as handsome as any orchid in a florist's window. The plant bears sometimes three or four, sometimes five or six, wide-spreading, butterfly-like flowers, gracefully set, as if just alighted, on the slim stem. They are bright rose-color, sometimes (nearly always in the bud) rose-purple. The petals and sepals are alike in color, broad, but finely pointed; the lip (on the upper side of the flower, not drooping lower than the petals, as in arethusa and pogonia) is crested with a tuft of delicate hairs, purple, yellow, and white. You will find calopogon in swampy places, among tall bog grasses, often, indeed, by the roadside; for it is, for an orchid, very common.

In among the same grasses you will find what at the first glance you may take for a pale, single calopogon, or a belated arethusa. This is pogonia (*Pogonia ophioglossoides*—there is a scientific name with a vengeance), less striking than calopogon, but quite as lovely. Like arethusa, it has but one flower (rarely two), a large, spreading blossom of a most delicate rose-color. The petals and sepals are broader than those of arethusa, and the broad lip, not marked with any stronger color, is wonderfully bearded and crested; and, most delightful of all, it has a faint but very sweet fragrance.

ROSALIND RICHARDS.

IN THE WOODS—AUGUST

THERE are still a few small wood-flowers to be found now, though for the most part the stronger-growing asters and goldenrods and the great wild carrot and wild parsnip tribe have it all their own way.

Here is a little flower as delicate as any of those of early spring, and with a name to fit its dainty prettiness—lady's-tresses (*Spiranthes cernua,* orchis family). You will find it in open fields and pastures, on the borders of woods,

LADY'S-TRESSES.

CHINA ASTER

SINGLE DAHLIA (Twentieth Century)

anywhere where it can find a little extra moisture. Like several of the flowers we have spoken of in June and July, it belongs to the great family of orchids, though in shape and growth it is quite unlike any of the other orchids that we have had. It is a slender little plant with long, narrow leaf, or leaves, at the base, and a single straight stem, on which the many small white, delicately fragrant flowers grow in three ranks, the stem being twisted toward the top, as it were, into a tight spiral, with the flowers protruding at every twist. The green of the twisted stem and the white of the blossoms make a delightful contrast, and the white of the petals and sepals, and of the crinkly lip, is of a peculiar glistening quality.

ASTER CORDIFOLIUS.

ASTER PUNICEUS.

There are several other varieties of lady's-tresses, among them *Spiranthes gracilis,* which has a stalk less twisted than that of *Spiranthes cernua,* and still finer and more delicate.

The glory of August belongs to the composite family, to the goldenrods and wild asters, that are making a wonderland of every ragged bit of roadside and common. I do not think I was ever prouder of the splendid profusion of our goldenrod, covering whole fields with gold as it does, than once, in the north of Scotland, in an elaborately laid out garden, where, as a rarity, I was shown a carefully grown border of *Solidago Canadensis,* one of our handsomest varieties.

The wild asters—and indeed the goldenrods—are so difficult to determine that the simplest course for the amateur is to avoid the long descriptions in the botany, and, when he has the chance, ask some one who knows.

Here are two of our wild asters,

however, that are more or less easy to distinguish. One, *Aster punicæus,* is a splendid plant, one of our very handsomest. It grows often to be six feet high, with a thick stem, many leaves, and quantities of great showy flowers, an inch to an inch and a half across, rich purple, with yellow centers.

The other, *Aster cordifolius,* is not so striking, but it is one of our commonest and best-loved varieties. It blossoms everywhere,—along the sidewalk, by the roadside, in the pasture,—but it is most beautiful in old sterile fields that have run out to June grass and juniper, where it grows in masses with the lovely slender *nemoralis* goldenrod, making field after field of pale blue and gold, with the dark warm green of the junipers to set it off. The beauty of one of these aster and goldenrod fields is so great that it comes back to your thoughts to color all the winter months.

This aster is a much-branching plant, usually about two feet high, though often as high as four or five, with a very great profusion of small star-like flowers, their rays varying from white to every shade of pale purple and blue. The leaves are heart-shaped, and notched, or serrate.

But it is not in summer that we can realize quite how much we owe to the roadside flowers, to asters and goldenrod, meadow-sweet and wild carrot. After the last bright petal has fallen and the last leaf has withered, long after the witchhazel has flamed in the October woods for a "lights out" signal, their beautiful seed-vessels, perfect and exquisite in shape, line the roadside with delicate tracery, or stand out over the snow, soft gray stars that for a while seem to have lost their light.

So we have their beauty with us all the year; so the woods grow more wonderful to us, till sometimes we cannot feel quite sure which is actually more beautiful, the silent, snow-warmed sleep of January, or the green, sun-lighted delight of the May-time.

ROSALIND RICHARDS.

LEAP-FROG BY MOONLIGHT.

THE STORY OF THE SOIL

HOW SOIL IS FORMED

Soil is that part of the surface of the earth which we cultivate, and which produces food for man and other animals. All soils consist chiefly of clay, sand, and lime, with other minerals, such as iron, potash, and soda.

The rocks of which this world was first made have been broken up by the action of the sun, air, water, frost, the roots of plants, by the burrowing and the throwing up of mounds by animals. Decaying leaves, and plants, and bodies of animals have also assisted in the formation of soil.

When we have dug or plowed the ground, and it has become nicely broken up and mixed with manure, we call it mold. Earthworms help very much in making mold. They make holes in the ground, and the air and rain get into these holes and render the soil fertile. As well as doing good by making these holes, the worms are always eating the earth, and when they have got all the goodness out of it they cast up the rest upon the surface in the form of worm-casts, so often seen on lawns and in fields.

When the worm-casts are dry, you can see that they are made up of very small particles; and after being spread on the surface by wind and rain they become soil, just suitable for such plants as cattle eat.

We dig or plow only the surface of the earth. The soil farther down, which we do not dig, is called the subsoil (*sub* means "under"). The subsoil makes a great difference to the value of the land above it. If the subsoil is stiff clay, the rain cannot sink through it easily; then the upper soil is too cold and wet to be good for plants to grow in, or for animals to lie down upon.

If the subsoil is very sandy, or consists of gravel, it may let the water pass through it too easily. Then the crops will suffer in dry weather. If there is hard rock underneath and only three or four inches of soil on the top, even if it is good top-soil, that land will need rain often, or the crops will soon droop for want of moisture.

A good kind of soil is deep earth with a subsoil of chalk. This kind will neither get too dry in warm, sunny weather, nor too wet in very showery times. This is because the chalk will let most of the rain pass through it, but keeps enough moisture for the crops.

Some soils are formed from the rocks upon which they are found, and are called "local," which means "belonging to the place." Others have been carried by rain-water from the hills into valleys. These are called "drift-soils." Some are formed by the fine silt, or mud, which rivers carry and spread out at their mouths. These are called "alluvial soils" (alluvial means "washed up").

"Warp-soils" are much like alluvial soils. They are made by letting the fine silt of tidal waters settle on the land. There are also lava-soils, which have been spread over large tracts of country by volcanoes, or burning mountains. What the volcanoes threw up was hot mud. This lava-soil is generally very good for the farmer to cultivate.

Then, too, we have peat-soil in many parts of the world. In Ireland it is called "bog." Peat is made up of decayed vegetable matter. It is often dug out in square pieces, and, when dried in the sun, can be used instead of coal for cooking and warming purposes. Where peat is now found, was once water.

A kind of moss, having the power of taking up moisture like a sponge, grew in these places for many ages, and, as the moss decayed, gradually filled up the space where the water used to be. At last the dead moss was turned into earth. If you drain peat-soils, and then add some lime, you can grow potatoes, oats, and such crops upon them.

Dark soils are generally better than light-colored ones, as they can take in more of the rays of the sun, and so get warmer.

The sunny side of a hill is more fertile than the shady side, even though the soil is the same; this is because the sunny side is warmer.

Some soils retain moisture longer than others, and so the crops do not suffer so much in dry weather. Heavy rains often wash the manure down too deep, out of the reach of plants, if the soil is too sandy. We call such soils light and porous; "porous" means "full of little passages or holes." On the other hand, soils which have clay in them hold the good qualities of the manure. We have to cultivate the soil, and break it up very small, so that the plants may thrive. They take up their food through their roots, in the form of liquid. Rough, lumpy soil would furnish neither plant food nor moisture.

The soil is the home in which plants live, and they get some of their food from it; but they get still more of their nourishment from the air and rain. They grow because of the light, heat, and rain from above, even more than from what their roots get from below.

IRON IN SOIL, VEGETABLES, AND BLOOD

If any intelligent boy or girl were asked the question, "Which of the common metals is the most useful to man?" the answer would undoubtedly be, "Iron."

A moment's consideration will show how important this metal is to civilized man. Ships, railways, engines, all kinds of machinery used in textile and other manufactures, agricultural implements, tools of every description, many domestic utensils, and scores of other articles are largely composed of iron, or of steel, which is a modified form of iron.

Without its aid, many manufactures, quick methods of travel, and the daily occupations of millions of men would be brought to a standstill, and we should be reduced almost to the helplessness of savage tribes.

It is not the mere usefulness of iron as an agent to man with which we are here concerned, but with another aspect of the case altogether.

Probably few children are aware that this same metal is needful to the existence of plant and animal life; and the object of these remarks is to note the wonderful part which iron plays in the economy of nature.

If the substance of which any plant or animal is composed be analyzed—that is, split up into the simple elements which together and combined make up the whole—it is found that the same constituents are common to plant and to animal life, although the *same* element is not necessarily present in the *same* proportions—in two different plants, for instance.

Every boy must have noticed that the hard, glassy stem of wheat or barley differs very materially from the stems of some plants—a dandelion, for example. Now the wheat and the dandelion contain the same fourteen elements, but the stem of the wheat is stiff and glassy by reason of the large proportion of silicon which it contains, while only a minute quantity of the same element enters into the composition of the stem of the dandelion; hence the great difference in the texture of the two.

It will thus be inferred that an infinite variety in the vegetable world naturally results from the varying proportions of these same fourteen elements in the different species.

There is one element, however, which, although not present in the same proportion in all plants, enters largely into their composition. That element is iron.

The green coloring-matter of all leaves is due to the presence of this element; and, although all parts of a plant contain iron, still it is much more abundant in the leaves than in other portions.

If this be the case, it will readily be inferred that a cabbage will require much more iron for its support than a plant with a very small leaf; and we should not expect the natural habitat of the two to be the same. Now consider for a few moments the case of animals as contrasted with plants. Chemical analysis proves that they contain the same fourteen elements as plants; and here again, owing to the different proportions in which these elements are combined, we find an infinite variety of animal life, just as in the case of plants.

With respect to the higher animals, the proportions of the various elements are much more uniform than in some lower down in the scale of creation. The tooth of a man and that of a sheep are similar in composition. The bone of both is composed of the same elements and in much the same proportions; the blood and the flesh are also very similar in composition; while the internal organs, although differing somewhat in shape and size, perform the same functions.

There are two things which are wholly necessary to animal life—air and food. Deprive an animal of either for any length of time, and it dies. The food is converted by the process we call digestion into blood, and the whole of the fourteen elements necessary to sustain life are found in this vital fluid—iron being among the number. The red color of the blood is very largely due to the presence of a compound in it which contains iron, just as the green coloring-matter of leaves is due to the same cause.

Iron being present in the blood, it follows that this metal must be present in some, at least, of

the different kinds of food, since whatever is in the blood must be derived from food or air. Iron being a solid body, while air is gaseous matter, food must be the source whence it is obtained. Now man lives on a mixed diet; but if we consider the case of an animal which feeds exclusively on vegetable matter, it is evident that if the blood of such animals be rich in iron the same element must be present in large quantities in vegetables.

We know that the blood of the sheep is rich in iron; and since sheep can, and often do, live on grass alone, it follows that grass must contain iron; otherwise it could not exist in the sheep's blood.

A further train of reasoning leads us to infer that because iron can be found in every blade of grass, and indeed in every green leaf, and vegetables derive their nourishment, or rather their solid food, from the ground, there must be iron in the soil wherever grass or any other green vegetable will grow.

It is a popular notion that iron is found only in certain localities of limited area. It is true that it exists only in these districts in such large quantities that it can be profitably extracted; but a teaspoonful of any fertile soil contains a certain amount of this metal.

The experienced eye can detect at once whether any particular soil is or is not poor in iron, by the color of the vegetation. Compare the grass growing on chalky ground with that in a rich river-valley, even in the same locality. The first is short and stunted, no matter how wet the season may be, and it never has the deep, rich, green hue of the other because chalk contains very little iron, and that as an impurity.

It would, therefore, be useless to attempt to grow cabbages or other plants which have naturally large juicy green leaves, on a chalky soil, because there is not sufficient iron mixed with the chalk to nourish such plants. Like weak, badly nourished human beings, they take on a pale, sickly hue; they become diseased, and soon die.

You will see from what has been said that animals get the iron contained in their blood from green vegetables; and hence, if our blood is to be of the deep red color that shows health, and that is due to the presence of iron, green vegetables must form an important part of our diet.

THE SOIL AND ITS USES

We are all rooted in the soil, and without the soil not one of us could be alive. It is an absolute condition of the existence of thinking moral beings, like ourselves, that the very outside of the earth's crust shall be changed into this stuff we call the soil.

The more we know about our world, the more clearly does it look as if life were its great purpose. We are to think of the planet as a theater, an arena, for life; and it is the life of the land, which breathes air, that reaches the highest. Now, when we examine into this life, we find that it all depends upon what happens at the very surface of the solid earth, where earth and air meet. We find, further, that the outer few inches of the earth's crust, or it may in some cases be a very few feet, become changed by the influence of air and water and light and life into something which we call soil.

We speak of soiling a thing, because the soil is rather messy, as if the soil were rather beneath our notice. But we know that animal life absolutely depends upon vegetable life for its existence, and we find that vegetable life depends upon the soil for its existence. So we may say that really everything that makes the existence of a planet worth while—that is to say, all the higher life which it nourishes—depends upon the processes which are ceaselessly going on just at the very outside of the earth's crust.

When we are in the country or at the seaside, we can see for ourselves what the soil means, because we can notice, for instance, at the top of a rock-cliff, a narrow layer which is evidently different from the rest. That layer is the soil; and if we study it there, we must understand that we are studying what goes on everywhere throughout the dry land of the earth, except in deserts, or where there is eternal snow and ice; and upon this process, which we can study so easily for ourselves, up to a point, is dependent the whole life of man.

If we look at the cliff from the beach, we see that a few inches at the very surface, instead of being white, are brown; the rock has been changed into soil by the process called "weathering." The brown color is due to iron, which is a necessary element of all life everywhere. Often the rain trickling down the side of the rock will carry a little of the iron with it, and so we may see little brown streaks staining the white surface of the cliff. Upon the surface of these few inches of altered cliff green vegetable life grows.

We know that every living creature requires nitrogen as part of its food; we know also that about four-fifths of the atmosphere consists of nitrogen, and so the surface of the soil, and anything growing there, are exposed to this gas. Also, we can readily understand that, as the soil is rather loose, there is a good deal of air in it,

and this soil-air, as it is called, also consists mostly of nitrogen.

So we should suppose that an ordinary green plant of any kind gets the nitrogen that it always needs, from the air in which it is bathed. We know that the green plant feeds upon the carbonic acid in the air, and we might suppose that, as it must have nitrogen, it feeds upon the nitrogen too.

THE NITROGEN WITHOUT WHICH LIFE IS IMPOSSIBLE

Now, we ourselves, and the lower animals, require nitrogen; but it is found that, though it passes into our blood from the air, we do not use it, and any one who does not get proteids, which contain nitrogen, in his food, will die of lack of nitrogen, even though his blood contains quantities of it. The reason is that he cannot use nitrogen except when it is combined with other things. Now, a very striking and unexpected fact was discovered about green plants several years ago: they are exactly like us in this respect. Carbonic-acid gas they can feed upon, though we cannot; but neither they nor we can use the nitrogen gas of the air. This was proved by some scientists about the middle of the last century. But it is perfectly certain that the plant must get nitrogen, and every one who has to do with plants knows that they must be supplied in the soil with compounds of nitrogen. The interesting question is: How are these compounds obtained?

We know that when there is a flash of lightning, or, indeed, whenever there are electrical disturbances of any kind in the air, a certain amount of the nitrogen and oxygen of the air combines and the compounds thus formed are largely carried down into the soil by the rain. So here is, at any rate, one source of combined nitrogen for the use of vegetable life, and it is a source which is in more or less constant action.

THE GREAT MYSTERY OF THE NITROGEN IN THE SOIL

But every one who grows plants knows well that for practical purposes this source cannot be counted upon at all. If he trusts to it alone, and there are no compounds of nitrogen in the soil to start with, his plants will not grow, and this, of course, is true of all the crops upon which mankind lives. Or, rather, to be exact, we should say that the plant grows until it has used up the compounds of nitrogen contained in the seed from which it started. When that is done, the plant simply stops growing. So, plainly, there must be some other source of compounds of nitrogen besides what the rain washes down into the soil from the air.

We know this, also, because in some parts of the world there are enormous quantities of compounds of nitrogen in the soil—quantities which cannot possibly be accounted for in this way. *Something else* happens in the soil, by means of which the free nitrogen of the air is made to combine with other elements, and so turned into compounds of nitrogen upon which the green plant can live. We say that the nitrogen is somehow "fixed," and this question of the fixation of the atmospheric nitrogen is one in which all the students of the soil are now deeply interested, and some wonderful things have been discovered.

HOW THE MICROBE AND THE PLANT GO INTO PARTNERSHIP

There is a certain kind of plants which has long been known to have a special power of growing and thriving even without a supply of those compounds of nitrogen which other plants need. The proper name for these is *leguminous* plants. They are so called because they form a thing called a legume; and we may know what that is because a pea-pod is a legume. Now, we find that the plants that produce pods like that—peas, beans, clovers, and vetches—behave as if they had the power of feeding on the nitrogen of the air. When we examine crops of this kind, we find that they contain far more nitrogen than can be accounted for unless the air has been drawn upon.

The men who began to study these plants found that they have tiny little swellings at various places on their roots, and that if they have not these swellings, they behave just like other plants, and cannot use the nitrogen of the air. Further, these swellings are only found on the roots of plants which have been affected by a little soil. If the plants are grown in sand, and no soil is allowed to get near them, no swellings appear on their roots, and they cannot grow unless compounds of nitrogen are supplied to them. There is, then, something in the soil which makes these swellings, and which gives the plant the power of using the nitrogen of the air.

It was next found that these swellings are filled with microbes of a special kind. A sort of partnership springs up between the leguminous plant and the microbe, and this is only one instance of several that we know in which two different kinds of living things make an arrangement of this kind between themselves. The pea

or bean, or whatever it is, supplies the microbes with sugar and starch, which microbes, not being green, cannot make for themselves, but which they find very useful. On the other hand, the microbes have the extraordinary power which no green plant has, of fixing the nitrogen of the air —that is to say, combining it with other elements. The compounds of nitrogen thus formed are handed over to the leguminous plant, which thus gets on just as well as if a rich supply of nitrates were being poured into the soil. So it was proved that microbes could fix nitrogen, but all attempts to make these microbes do the same for other kinds of plants, as, for instance, for wheat, failed completely. The arrangement will only work between these microbes and leguminous plants.

THE ENERGY THAT THE NITROGEN GIVES TO THE PLANT

Plainly, there was much more to be discovered, and that has now been done. The probability was that as there were microbes which could fix the nitrogen of the air, we should find other microbes, perhaps living free in the soil, which could also fix nitrogen, and could thus supply compounds of nitrogen for green plants in general, trees and grasses, including cereals.

Now, there is a very important point which we must understand here. When we take nitrogen, and combine it with anything, power or energy is stored up, as we say; in other words, there is more energy in the compounds of nitrogen than there is in nitrogen itself. This energy is, of course, wanted and used by the green plant. But nothing comes from nothing. If we make compounds of nitrogen in the chemical laboratory, we know that, according to the quantity we make, so must we spend a certain quantity of electricity or heat; just as when compounds are naturally made in the air by electricity. Now, though life is a miracle and can do marvelous things, it can neither create nor destroy energy. It is a transformer, but not a creator. If a microbe makes a compound of nitrogen, it has to get from somewhere the power to do so, just as the chemist must when he does the same thing.

HOW THE MICROBES FEED PLANTS WITH NITROGEN COMPOUNDS

This means, indeed, that if the microbe is to make compounds of nitrogen, it must be supplied in its food with power which it can put into them. In the case of the microbes that live on the roots of leguminous plants, the power comes from those plants; that is part of the bargain between them, and it comes mainly in the form of things like sugar and starch. These things contain power, for they make us strong, and when they are supplied to the microbe, it puts the power of them into the compounds of nitrogen which it makes.

But, now, this is very serious, for the green plant requires nitrates, but the microbe requires the help of the green plant before it can make the nitrates. The first question we must ask is: Where does the energy come from, in the first place? There is no difficulty about the answer. The energy comes from the sun. It is the power of sunlight that is stored up in the sugar made by the plant. It is that power which the microbe takes and puts into the nitrates it makes. Now, in certain parts of the world, we find soils which contain a very huge quantity of nitrates. In Russia, in Manitoba, and in the Argentine, we find these rich soils, which are, of course, the joy of the farmer, and which grow the most magnificent wheat.

HOW THE POWER OF THE MICROBES COMES FROM THE SUN

We are certain that these nitrogen compounds have been made by microbes; not the same as those which live on the roots of leguminous plants, but others. But the law that all power must be accounted for has to be reckoned with. Where has the power come from which the microbes have used? It has come from the sun by means of the green plant. The whole meaning and explanation of these wonderful soils is that, for a long time past, natural vegetation has been growing upon them, catching the power from the sun and turning it into substances which fall into the soil, and feed the microbes, and so enable them to fix the nitrogen of the air.

The discovery made about leguminous plants really applies to all green plants. The leguminous plants have a special arrangement of their own, and the special microbes with which they are in partnership actually live inside their roots. But what is true of them is true in essentials of plants in general.

THE MILLIONS OF USEFUL MICROBES THAT LIVE IN THE SOIL

We are now beginning to get an idea of the complicated character of the soil. Words cannot describe how crowded it is with microbes of all kinds. The surface of the soil is always receiving additions of matter from previous life, leaves,

and stalks, and so on. Then there are animal remains, and so on, added to it, not to mention the manures which are added to it on purpose. All these things, as they pass into the soil, are rapidly changed, and it is very easy to prove that these changes are all due to microbes. If we take some soil, and heat it so as to kill the microbes in it, all these changes stop; or if we add to the soil something which kills microbes, such as chloroform, then also these changes stop. That, of course, is the last thing that we wish to happen, for most of these changes which go on in the soil serve to prepare the food for the green plant.

Now, the ordinary chemistry of the soil is, of course, very important. We must remember how tremendously important is the difference between an acid and an alkaline soil; and it is very important that we shall add to the soil, in certain cases, certain chemical substances, such as nitrates and carbonates, and salts of ammonia. Often, however, we may do more harm than good if what we add upsets the balance of power among the microbes in the soil, and we are learning more and more that it is really the living microbes, and not the lifeless chemicals, that decide what the result shall be. And so the question arises whether our new knowledge of the soil may not help us to feed it with microbes of the kind we want, and so to get even more success than by feeding it with any chemicals at all.

LAZY MICROBES THAT WOULD NOT WORK FOR THEIR LIVING

Students of the subject began by getting hold of the microbes which they found on the roots of leguminous plants. They managed to grow them by themselves, just as the microbes of consumption, and so forth, can be grown. And then they thought to apply these growths to the soil. They failed at first because the microbes, having been too well fed in the laboratory, had turned lazy, and simply would not work when they were put back into the soil. This is just one more instance of the universal truth which applies to every living thing and every part of it. Instead of having to work for their living, the microbes had been fed in little glass tubes with all sorts of nice things, which no doubt made them feel very fat, and plump, and comfortable, but made them useless, like all persons who are over-fed without having to work. However, that difficulty was got over; but even then it was found that either one kind or another of desirable microbes is *already* present everywhere in the soil.

A great many people believe that this feeding of the soil with living microbes is very useful; but, on the other hand, many other people are not yet sure that this has really been proved. Time will show, and, at any rate, there is little doubt that if we cannot yet do what we desire, we shall be able to do so soon. Now, there is a most important matter which we must insist on. When we use up coal, or so-called mineral oil, we are really using up the great capital of wealth which has been accumulated—saved up from the sunlight of past ages, by the plants which were then alive.

HOW THE SUNSHINE OF THE PAST FEEDS THE CORN-LANDS OF TO-DAY

And now we learn that in the new countries where men are growing crops to feed ever-increasing millions, mankind is also living upon its capital. It is true that, in the great wheat-lands of Manitoba, for instance, the capital may be enormous, but it is not endless. The green fields of wheat which cover such a great part of the earth to-day are, of course, using the sunlight of the present. We know that they could not grow without that. But if that were all they had to draw upon, they could not grow as they do. In the main, they are living upon the sunlight of the past, just as much as if we had to feed them upon coal, as we have to feed machines, which are not alive. The soils which are wealthy now are the soils which have saved before now. Let the soil of a piece of land be left alone for a quarter of a century, and it will become rich because men do not come and take away from it the wealth it made from year to year.

SOMETHING THAT NEITHER NATURE NOR SCIENCE CAN DO

They think that when the coal is exhausted, or when the rich soils are exhausted, science will supply something else. Now, science can do wonderful things, but it cannot make something out of nothing, for the very good reason that not even Nature can make something out of nothing. Science may learn how to use to its best all the sunlight that falls upon the earth at the present. But when we have used up the sunlight of the past, as we are now doing, that is all mankind will have to live upon, for we cannot borrow the sunlight of the future. These are great questions which thoughtful people must begin to think about unless posterity is to turn upon us, and call our age the age of blind waste.

STORIES ABOUT DOGS AND FOXES

WHERE DOG IS KING

BY LIDA ROSE McCABE

NOWHERE in the world has the dog such unrestricted right of way as in our most northerly possession—Alaska. In winter when the more than 600,000 square miles of territory are sealed up in solid ice, dogs are almost the sole means of getting from place to place—in fact, they seem necessary to life itself.

No one, not even his brutal native master, begrudges Eskimo dogs their summer vacation. To the stranger who first stumbles upon them in that season, when their shaggy hulks sprawl across cabin doors and obstruct foot and wagon traffic on the board roads or walks of mining-camps, they seem a hopelessly lazy, greedy pack of vagabonds—the very dregs of dogdom. Every Alaskan town swarms with dogs. On foot or on horseback, we are forced literally to walk over them. No amount of cuffing or yelling will bestir them if they are indisposed to be off. In summer their sluggish blood and worn-out legs respond only to a fight. They are never too old, too tired, or too hungry for that. When not in harness or asleep they are always "scrapping."

It is rare to find in the arctics a dog with nose, ears, or legs unnipped by the cold. The favorite summer sparring-ground of the dogs of Nome—our most northerly seaport—is the sand beach lashed by Bering Sea. There they wrestle with the skill of gladiators.

In speed the "outside" dog, that is, the dog from Europe or the "States," shows off in camp to the disadvantage of the native, but once on the trail, the latter is the Arabian steed of the arctics. It takes the frost, the compelling force of the Great White Silence to put mettle into him, to rouse his Siberian wolf ancestry. Every drop of blood, the tiniest hair in his shaggy coat, which he sheds in summer to take on in winter with renewed thickness and luster, responds to the call of Jack Frost.

The aristocrats of arctic dog life are the mail teams in the service of the United States government. They are to-day a superior breed to the dogs employed some half dozen years ago before great gold discoveries demanded increased mail service.

Until the coming of American civilization, leaders in Eskimo dog teams were unknown in the arctics. The trail was broken by an Indian or Eskimo, generally a woman running ahead of the team, her tiny mukluks—which are high boots made of the skin of the hair seal or the reindeer—pounding through the snow, while her liege lord snuggled in the sledge's fur-lined bed.

To-day, woman is supplanted by dog as leader. Not to white man's chivalry or gallantry is the innovation due, but to the fact that the dog makes a better leader.

Few pure malamutes (native dogs descended from the Siberian wolf) are now employed in the mail service. Their legs are too short, their feet sink too readily through the snow. Preference is given to a cross between the malamute or "McKenzie huskie" St. Bernard or Newfoundland with a little hound.

The Eskimo begins to train his dog for sledge work before it is a month old. One of the most interesting features of Eskimo villages are puppies tied to the pole of a tent. They pull on the rope with all their puppy strength in the effort to break away and join in the frolics of their elders.

A RESTING DOG TEAM JOINING IN A CANINE CHORUS.

Not until a dog bred for mail service is one year old is it put in training for the trail. It begins by running ten miles with the team, then it is dropped out. Next day it runs the same distance. Gradually the distance is increased until it reaches its fifteenth month of life when it becomes part of the regular service. The life of a mail dog is from three to four years. No greater punishment can be inflicted than to lay a dog off from service. When unruly they are often threatened with a lay off, and with almost human intelligence they seem to understand the disgrace it implies in the eyes of their fellow-workers on the trail. All fight to be leaders. A constant spur to an unambitious dog is the "outsider" who will quickly take away the leadership not only in the mail service, but in teams maintained chiefly for the pleasure of the sport. The intelligence of the malamute is remarkable, its scent wonderful, its instinct, as a rule, unerring.

Some dogs are better trail followers than others, as some are better leaders. In a blizzard

THE UNITED STATES MAIL, ONE MILE FROM NOME, ON THE BERING SEA, ALASKA.

AN ALASKAN MAIL-CARRIER—A HALT ON THE JOURNEY.

the best of them lose the trail but invariably find it. When on the trail they never eat but once a day, then at the end of a journey. After feeding, like weary children they fall asleep and are never quarrelsome. It takes on an average twenty pounds of food a day for a team of eleven dogs on a hard route.

In the winter of 1907 thirty dogs were employed in the mail service between Nome and Unalaklik. The next season the number was increased, each of the two carriers having an assistant, a provision of Congress thus assuring the peninsula the receipt of second-class matter—a luxury heretofore denied invaders of the frozen North.

Yearly the dogs manage to consume several tons of bacon and rice. The rice and bacon are cooked together with frozen fish and eaten hot. The dogs are permitted to eat all they want. When too hot they let it cool in the snow. If near the sea or a river they will cunningly pull the vessel out on the ice, and test the temperature of the contents with their long tongues until the mess can be eaten without burning the mouth.

Frozen fish is the staple food of all native dogs.

Once a week the dogs are fed on fresh meat bones. The mail-carriers generally prepare the dog food themselves rather than intrust it to road-house keepers. In severest weather the dogs are unprotected save by the thick coats of hair that nature provides. When a road-house is reached, they often share its shelter with the carrier, but not infrequently they burrow deep into the snow-drift and, curled up in their warmth, wait until bidden to move on. Often while the master tarries but a few moments in a road-house, the snow will have fallen so thick that his team will have completely disappeared, their sturdy little forms making rows of hillocks in the Great White Silence of the sleeping world. In April and May the mail dogs wear moccasins of moose or deerskin, for the thaw of the spring sunshine freezes at night and the ice cuts their feet.

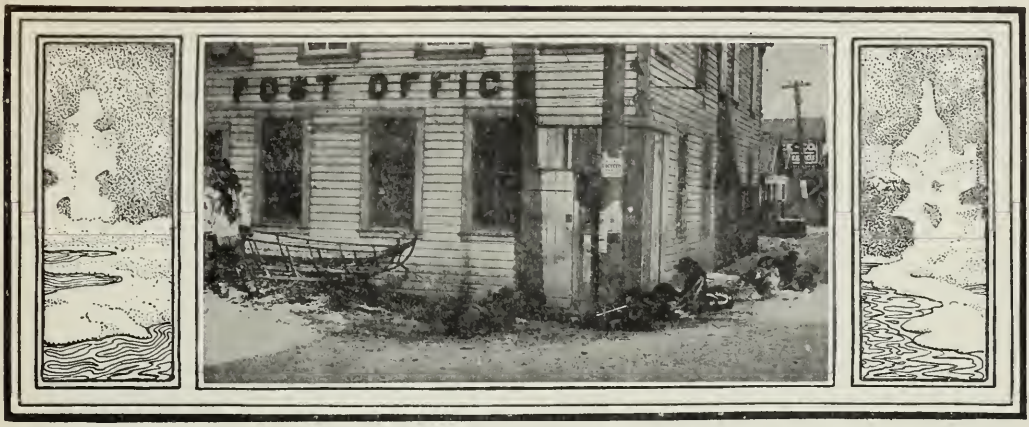
Mail-carriers own all or part of their teams. The dogs are to them almost as their children, so fond of them are they. To their cry: "Hee! Haw! Gee! Whoa! (that is: Right! Left! Go! Stop!) they respond as to no other. Once on the trail, the dogs are swifter than the wind; unmindful of every discomfort, every danger, bent only on making time—safely delivering the mail. Their one playing truant from the line of duty is chasing the snowbirds that flit across the trail. So enticing is this sport that often the driver is at the mercy of the team, which quits the trail and in eagerness to catch the flying coquettes of arctic winged life, roll the sledge over and over snowbanks until the birds are theirs.

A ROUGH BIT OF THE POST ROAD.

Nome is the mail distributing depot for Seward Peninsula—the gateway to northwestern Alaska. Mail from the States comes from Seattle by steamer to Valdez—four days' journey. From Valdez to Nome is an overland route of more than 1500 miles. This distance is covered by four dog-team relays, each let by the government to a separate contractor.

The government pays the contractor a certain sum each year for carrying the mail from Unalaklik to Nome. Out of that sum he pays all expenses.

He constructs the sledges, makes the harness and enters into the scientific training of dogs for the service, so he has plenty to do for his fee.



A DOG TEAM RESTING AT THE POST-OFFICE.

Unlike most of the high-bred dogs of Nome, the mail teams are not kenneled in summer, but follow their masters, who, like every one in the Northland from parson to scavenger, have mining interests, and "work" their mining properties in summer, when not on the trail.

Despite a winter's strenuous work, mail dogs are physically in better condition at the end than at the beginning of the season. In weight they are heavier at this time, while their coats are thick and glossy. During the short arctic summer when the sun never sets, they saunter about the camp with a very important air. Theirs is the center of the stage. Their wild entrance and exit four times a season when the whole population for miles around gathers at the post-office to greet the mail-carrier with his long, long expected tidings from the "outside" has schooled them to love the glory which is theirs.

UNITED STATES SIGNAL CORPS DOG TEAM, FORT DAVIS, ALASKA.

The Alaskan native dog is very fond of children, and is always affectionate and playful with them.

BY F. H. THROOP

I WISH I could tell this story to you as it was told to me, by the light of a great log fire, making ever-changing pictures on the rough walls around; with the wind whistling outside; the low whine of the dogs and the flash from the lantern in the refuge tower startling you suddenly every now and then, as it startled us that night on the mountain; with "Turk's" skin beneath our feet, and his photograph on the shelf above, how real it would be to you! And how it all comes back to me now—the grim old hospice of St. Bernard, the quaint prints on the walls, the eager faces of the group, and the firelight. These surroundings made the story very real; and before it was finished the young monk who repeated it buried his face in his hands and shuddered. This was *le Père* Joseph Luisier, the youngest and bravest of all the brave monks of St. Bernard; and well he may have shuddered, for he and a boy were the only survivors of that terrible night. Turk saved them, as Turk had saved many another—Turk, the beautiful, brave St. Bernard dog.

Away up among the highest mountains of Switzerland there is a narrow defile, or opening in the solid mass of rock, leading from northern Italy to the Rhone valley, where the hills are covered with vineyards and the fields overflow with corn and grain. For many centuries this pass has been used by poor peasants, usually laborers on foot who can not afford other means of crossing the mountains. Unprepared for the difficulties of a mountain climb, without much food, thinly clad, wretched and ignorant, they start on a journey which would often end in death, save for the charity of a company of monks who devote their lives to saving travelers.

In the monastery situated at the highest point of the pass are fifteen or twenty Augustine monks, most of them under thirty years of age; for after fifteen years of service the severity of their duties compels them to descend to a milder climate. Their office is to receive and lodge strangers "without money and without price," and to render assistance to travelers in danger during the snowy season, which here lasts about nine months. They are aided by the famous St. Bernard dogs, whose keen scent enables them to discover travelers buried in the snow.

"Have you ever heard of Turk?" I asked the guide, a lank fellow in blue blouse and bonnet, who was strapping upon my mule's back a heavy woolen coat. He dropped the strap as I spoke —his eyes filled with tears. "I was two years at the kennels, sir," he answered. "Turk and I were *confrères,* and when he was gone I could not longer stay. I act as guide to show visitors about the place now and then. I can't go far away, but I can't stay now Turk is no more. You know the story, sir? No? Well, they 'll tell it to you there," and he pointed across the dreary waste.

We paused on our way, for a moment, at the stone châlets, where the monks make butter and cheese for winter use—a true Alpine dairy, fresh, neat, and clean. Here the road ends. We buttoned our coats tightly and crossed the plain to the dreary "Valley of Death" beyond. The sun was obscured; the cold was intense. From the great rocky basin in front of us there seemed no escape. I wondered how our guide could pick his way. Any of the opening paths about us looked surer than the rough, winding one he chose. As if answering my thought, he fell behind the forward mule he was leading, and pointed ahead to a jagged opening far up the ravine. "That is our landmark. If we lose sight of the further crag we may be lost. That is where Napoleon, crossing in 1800 with thirty thousand men, nearly lost his life by the slipping of his mule on the verge of the precipice. The mule fell and was killed. Napoleon was saved only by his guide, who caught him by the coat; and right here, sir, is where they dismounted the cannon, set them in the hollow trunks of trees, which half of the soldiers dragged up the mountain, while the other half carried the guns and luggage of their comrades. Those were good old soldiers. I wish they would come back again." He spoke impatiently. "Ah, sir! I wish I could see the world! I have never been beyond St. Pierre, but I have crossed the pass to Aosta, and some day I will go to Italy, if ever Napoleon passes this way again." My heart was touched for this poor peasant lad living all his life in the lonely valley, with his hope for the future centered in the expectation that Napoleon's army

would "pass that way again!" A little later we stopped by a heap of stones. A wooden cross leaned from the center and upon it was rudely cut the word "Turk." "I did that," he said proudly. "Turk is not there, but the peasants are. This is where Turk found them, and the veurra* caught the monks!" Again I urged him to tell the story, but he declined as before. Evidently the subject was too painful. "I must watch the path," he answered.

On we went, over ruts and stumps of fallen trees. At last, hidden among great boulders, we found the pass, half choked with drifted snow in the middle of July! We crossed icy streams—small glaciers in their way, the frozen surface firm, while water rushed beneath—scrambled over broken masses of rock, hurled by some freak of nature from the heights above; and toiled up through ragged defiles. Before long, turning a bend in the gorge, we saw the monastery of St. Bernard—a mass of cold gray stone against the purple sky.

Unutterably lonely, weird, desolate among bare rocks, ice-bound cataracts, and snow-crowned mountains—we were chilled from head to foot in July. What must it be in winter? At first, it appeared like some ruined château. There were beggars hanging on the outskirts, and paupers gathered about the arched doorway; young Italians with their packs on their backs; mountaineers returned from the hunt, with guns and game-bags; guides; young Englishmen "tramping it" through the Alps; and wanderers like ourselves, all alike welcomed by the great glowing lantern which shed its rays far into the pass on both sides. I was not astonished when the young priest told me, later, that often they have lodged six hundred strangers in a night under that hospitable roof.

Le Père Joseph Luisier was in charge; a young man full of life and energy in every line of the figure draped in the long black cassock. He came courteously forward to meet us. Had he been a polished man of the world, receiving guests in his home, he could not have welcomed us more graciously; and yet, as he did so, he had not an idea where he should put us for the night. Asking us to wait a moment, he went away with a perplexed look, rubbing his chin. He soon returned, running lightly down the stone stairs, three steps at a time, like a boy. This quick step was characteristic, as was also the laugh (the merriest I ever heard) with which he explained his perplexities. It had stormed steadily for two days; visitors had stayed on; more had arrived, and some Italian priests on their way to France were spending a few days. Every nook and corner was full, but these priests had offered us their apartments, and would lodge with the brothers. Thus it was arranged, and we found ourselves in the rooms of honor, comfortably furnished, and with beautiful St. Bernard dog-skin rugs on the floor. They sent us dry shoes and clothing, offered us hot drinks, and right royally received the American strangers.

After dinner the room was cleared, except for a few of us around the flaming logs, listening to the crackling of pine-cones within and the roaring wind outside, while Père Luisier told of their winter life, the dreariness of their lone vigils when all the wayfarers are poor, the cold is intense, the snow is at great depths, and fierce storms are ever threatening their strong monastery.

"And our dogs?—God bless them! Why, without them we should be helpless, indeed. Let in the puppies, Jean. I must show these Americans my jewels."

A figure moved from the dusky corner opposite, and I recognized the admirer of Napoleon's army, who returned in an instant, with all the pride of a full-blown soldier, bearing in his arms a mass of down, which, upon being placed on the floor, resolved itself into three great awkward puppies—balls of yellow and white fur that rolled about helplessly in the confused firelight or balanced themselves on most unsteady legs. The mother dog followed closely, a very intelligent animal, with soft eyes and a gentle manner, crouching low beside her master, or standing erect for service as the call directed.

"We have waited for your coming to name them, Jean," said Père Luisier, affectionately laying his hand on the boy's sleeve; "if you like we will call this fellow 'Napoleon'" (the boy's idea was not unknown, then, to Père Luisier), and he laughed as he indicated a very round little pup whose four paws were at that instant waving heroically in space—"and that brown one, the boys ask to name 'Léon,' after our good Father Morton—and this?"

The priest lifted up the smallest of the three. Although the youngest, he bore an air of determined courage in his bright little eyes. The boy hesitated.

"Father, I wish you would call him—call him"—their eyes met. The boy's lip trembled, and seizing little "Turk," he carried him from the room. Père Luisier rose abruptly.

"The boy almost unnerved me," he said. "I will return directly." And gathering the remaining puppies in his arms, he retired, followed

* A whirlwind of the Alps which suddenly raises immense drifts of snow.

ST. BERNARD DOGS.

by the majestic mother dog. Presently he returned loaded to the chin with fire-wood. "One must not come empty-handed," was his reply, when we remonstrated because of its weight. "That boy Jean has taken a great fancy to you, sir," he added. "He wants me to tell about Turk, and I must have a good fire before I begin, for it 's a cold story at best. This is Turk's skin, sir. I keep it here beside the logs where he liked best to stay when off duty, and this is his photograph, and this, his collar. Turk died in harness, as, please the Lord! will I."

He crossed himself, threw more pine-cones on the fire and began the story:

"It happened two winters ago, on a night when the wind had taken down every standing thing about us, and only the hospice and monastery remained. All day long I had heard the boulders rolling down the mountainside; but the whirl of snow was so blinding I could not see my hand before my face. Still the sound was enough—I knew the rocks never fell alone, and I prayed God there might be no travelers on the pass that night. Each day we visit the 'refuges.' You perhaps noticed them, sir—the stone huts along the pass. They are kept open during the winter, a bed in each, a fire ready to light, food and brandy on the shelf. Peasants who reach one can wait in comparative comfort till we come, and many are the poor souls we find sheltered there. How do we go? Simply enough—priests and dogs, hand in hand, as it were. First in line, one of the dogs leads, his 'barrel' attached to his collar; a coat strapped on his back; a rope from his collar, passing through the strap, is tied about the waist of the first brother, on to the next behind until all are attached in line of march. Sometimes there are two, sometimes more, according to the difficulties of the weather. Heavy rubber coats lined with fur, high boots, a long spiked pole in the hand, an axe and shovel strapped across the back, such is the uniform of a St. Bernard monk on duty. At daybreak we begin the descent, feeling our way step by step, often stopping to cut a path through a bank of snow and ice; and should the dog in front disappear, falling suddenly forward, we know there is a dangerous crevasse ahead, and, dragging him out, we go on more cautiously.

"On that day it was my morning off duty; I stayed in the library at work on my papers and books; at noon the Piedmont party* returned; about two, I heard the call of the Valais men coming up the pass; it was the 'distress cry,' and we all hastened to help them in with two poor fellows that they had found in the first refuge. The priests had been told by them that they were alone. But in the warmth of the fire, one began to sob, confessing they had lied, and begging us to save his brother. The truth was soon told, and to our horror we found they were two from a party of five, who had left St. Pierre the day before, and been overtaken in the storm. There was no time to be lost then—no word of reproach was spoken to the poor wretches who, to save themselves, had concealed their comrades' fate. Father Léon and I were the only men in the monastery who were fresh and unwearied. It was folly for the others to talk of joining us, and they soon gave up the idea. All the dogs had been out often, too, and the day had been unusually hard. We would not force them out, but I went and stood a moment at the kennel door. Turk instantly jumped to my side, running to and fro from his harness to my feet, and I knew he was ready and willing to go. Jean was here in those days, and when he found Turk was going, he begged to be of the party; I refused once and again, but he loved Turk like a human brother, and there was no keeping him back; he was a strong lad, knowing every foot of the pass. So it was not in my heart to refuse him, on the Lord's errand, remembering the work we had in hand, there being only two of us for the three below there in the snow. Jean was ready on the instant. And out we went into the blinding storm, leaving the door just as the clock struck the half-hour after two.

"It was terrible. Turk led the way, plowing along like some great engine; I followed; Jean came next, and Père Léon last. We sank knee-deep, constantly lost our footing completely in snow-drifts, or found ourselves about to fall into some chasm, from which we hauled one another. We were three hours in reaching sight of the first refuge. There was no building to be seen, but we knew the direction, and turning off began to dig for our lives into the great bank. The snow had ceased, the air was clear and cold, darkness had overtaken us and we were almost exhausted. Ah! that was cheerless work, digging our way into the little hut, but we were rewarded at last; Jean's shovel struck the very door, and in a few minutes we were fanning into flame the smouldering remains of the morning's fire.

"To find the travelers, get them to the refuge that night, give them the care which alone could save their poor half-frozen bodies—this was our one thought. We waited only to get some of the

* The monastery stands on a height, between Piedmont and Valais, cantons of Italy and Switzerland, the boundary being marked by the national shields, cut in the rocks.

numbness out of our feet and hands to rub up the lanterns, place a light on the bank outside, and then were off again, this time even more cautiously than before; for now we must swing the lanterns far out to either side, push the snow to right and left, and begin that dreary search which in its eager intensity can never be described—and, thank Heaven! there are few who know it from experience!"

Père Luisier paused here; his strong face looked gray in the firelight.

"Ah! it is so hard to tell these things; yet, if the world knew more of what we suffer, it would perhaps be more eager to send us the help we so much need. But, enough—we found them. Turk tracked them from the hut by scent, following back the steps of the rescued ones, and not far away they were lying just under the snow. One was past help. The other two we carried to the refuge, and when morning came they were able to take their coffee and start with the rest of us.

"We had gone perhaps a mile, when we heard the low rumbling and whirling of the wind among the distant mountain peaks. Turk, who was in advance, turned and slunk back, his tail between his legs, his great head held low upon his shoulders, as I have never seen dog do before or since; he trembled all over with fear, and neither by coaxing nor by threat could he be persuaded into the defile before us. 'Turk knows best,' said Jean, 'let us go back to the refuge while there is time! it may be an avalanche—or—or something worse!' None of us dared to whisper 'a veurra!' but each silently thought of that terrible wind, which comes sweeping down the mountains, whirling rocks and earth, man and beast into one horrible abyss, and devastates the mountain as a cyclone does the plain. We made what haste we could, but the noise behind us grew in intensity, thundering from peak to peak, and the air was full of sand and whirling snow. In less time than I can tell it, we were overtaken. I saw the peasants throw themselves face downward; I saw Father Léon drop on his knees in prayer; I saw Turk leap forward, throwing Jean to the ground and himself on the form of his prostrate master. Then I saw no more, for the snow blinded me. I felt myself lifted from my feet and dashed to earth, and then I knew the veurra was upon us! Still I was not unconscious. I remember wondering why we were not borne away, as was everything around us. I knew that I was conscious, and I knew that by some marvelous providence I had been saved from a horrible death. I tried to move, but I found myself lying under a narrow ledge of rock; the snow was packed tightly around me; at each movement I could feel it fall more closely about me, and I knew that unless I lay perfectly still I should be buried beyond hope of rescue.

"As it was, I believed that life for me was over—they could never find me there. By some chance a mass of snow had fallen, before the veurra struck us, or at the same time, and I resigned myself to God's mercy and to the death I had always expected to overtake me.

"At the hospice all was ready. The night before, prayers had been said for those in distress; and as day dawned, five of the brothers prepared to meet us on the pass; but, before they had started, the veurra was seen, and all exit from the hospice was simply impossible. With agony they watched it rise; at solemn mass they commended our souls to Heaven; and as the whirlwind abated they started on their dismal quest for traces of the missing four. For hours they continued their hopeless search; the refuge was uncovered, the wind had swept the pass clearer than it had been since winter set in. They found our breakfast bowls at the refuge, and knew by the surrounding disorder that the travelers had been found, and resuscitated there; but beyond there was no track or trace of any of the party. Disheartened and discouraged, they slowly retraced their steps.

"Suddenly there was a shout! One of the party had discovered a drop of blood on the white surface of the ground, then another, and yet another! What could it be? They fairly ran up the pass, guided by the blood drops in the snow. Not many yards farther, they came up with Turk, staggering inch by inch toward home. When he saw them, he gave a joyful whine—his mission was fulfilled! Turk fell exhausted before them. There was no time to stop; they placed a coat beneath him and went back again. It was easy to retrace their steps now; easy, too, to find where the red marks turned from the path in which they had first seen them. Ah, how the dog had struggled to save his masters! The round hole in a harmless-looking bank of snow was stained too—stained for many feet, into its heart, where lay buried five human lives. Halfway in they found Jean, his clothes torn and ragged, showing that the dog had attempted to drag him out. I heard them working long before they came to my ledge. I heard them call my name and wonder why I was not with the others. Heaven only knows how I came where I was. I made one great effort, my arm pierced through the drift, and in an instant they were beside me, pushing away the snow from my frozen legs, chafing my numbed hands, and bringing back the

life to my dizzy brain. Shall I ever forget that day? I know not how they carried us home. I only know that Turk had saved us, Jean and me. He did what he could for all, but only Jean and I reaped any benefit; and when they brought poor Turk back he had a bed made in our dormitory, and used to come and lick our hands (Jean's bed was not far from mine) and look almost human. His back was covered with plasters, and his legs bound up like a wounded soldier's; he had been badly cut by the ice and snow, and the front paws with which he had dug his way out were quite helpless. Long after Jean and I were about, he would lie for hours beside the fire. They said the wound in his head could never heal—and it never did."

Père Luisier buried his face in his hands and wept like a child. "You 'll pardon me, messieurs, that 's all the story of Turk. I can sometimes tell it without breaking down, but not when that boy Jean comes up. Jean was to have taken orders, sir—but that is all past; he can't stay here without Turk, and I do not urge it, knowing myself how hard it is. He has a fancy to join Napoleon, some day. I never explain it to him, for Jean is a good lad, and a good guide, but—" he touched his forehead significantly as he spoke.

"Would he come with me to America, Father?" I asked. Père Luisier shook his head. "No. Do not ask him, sir. He is far better here, and I look after him. We are all better here, even Turk," and stooping he caressed the skin at his feet as if the good dog lay napping there.

When we went to our lonely cells I was trembling with excitement, and felt thankful that mine was only a twenty-four hours' stay in this desolate region. Next day we had a last few words with Père Luisier, promising to remember always the hospitality he had shown us, a last frolic with the dogs, and then we were off. Back into the "Valley of Death," over the snow with our hands full of flowers, and the hospice of St. Bernard growing dim in the distance. Jean was disinclined to talk, and we walked on silently. I wished to tell Jean how I honored him for his bravery, and I expressed it awkwardly enough, while he held my two hands as I said good-by.

Five minutes later, however, I saw his blue blouse and cap in the road ahead. He had taken a short cut through the woods and stood waiting for the wagon. As we passed he thrust a roughly tied roll under the seat and blurted out fiercely: "Take this with you. Père Luisier gave it me, but I would rather you took it away. I

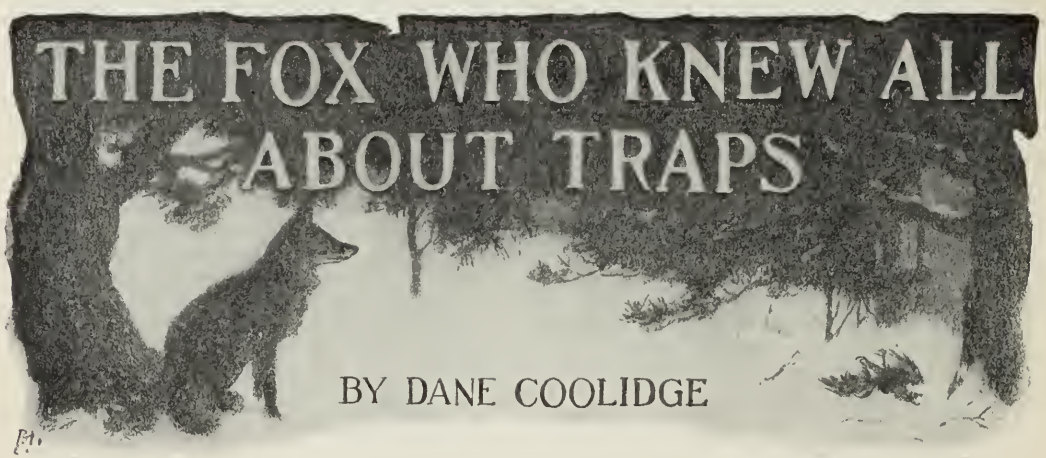
ASLEEP NEAR HIS HOME.

can't bear it, sir. *That* is not Turk!" and he was gone in the forest before I could jump down to follow him. The roll contained Turk's skin.

So I came into possession of Turk's skin, and I took it with me to Paris, to Dresden, to Munich —where I parted with it, as I shall tell you.

A white-haired Englishman sat next me at table d'hôte—a crabbed specimen, I thought—and our conversation was usually upon the weather. One day I spoke of Switzerland. His whole face changed. In an instant we were talking like old friends. "Do you know St. Bernard?" I asked. His countenance fell. "I have just returned from there," he answered. "I went on a sad errand, and I return sadder than I started. Have you ever heard of Turk?" he continued, and not waiting for my reply he told shortly in outline the story I knew so well; adding, "I was at the hospice when Turk was born. Every summer since, I have gone back to see him. He always greeted me and knew me, and many a time have I offered any sum to the monks to own him; but they would not give him up. Last winter I heard that he was dead. I felt as if I had lost a friend. I wrote to ask for his skin, and receiving no reply, I have been to get it myself." "Well?" I asked, thinking I must say something. "Well, some shrewd American was before me! Begging your pardon, sir, it 's a nation given up to gain. I wager the fellow will give lecturing tours, with Turk's skin, all through the States! And I—I loved that dog. I would give a thousand pounds to find the man!" "Save your money, sir," I answered. "It 's enough that you loved the dog. I am the American! You are welcome to Turk's skin!"

I felt as Jean did: "*That* is not Turk!"



Once there was a fox who lived on a high mountain in California, and he knew all about traps. His name was Silver-gray, and his winter coat of fur was so beautiful that any lady would be proud to wear it. In fact, so many ladies wanted to wear fur like his that merchants offered a great price for his skin and for the skins of all his brothers, the family of silver-gray foxes.

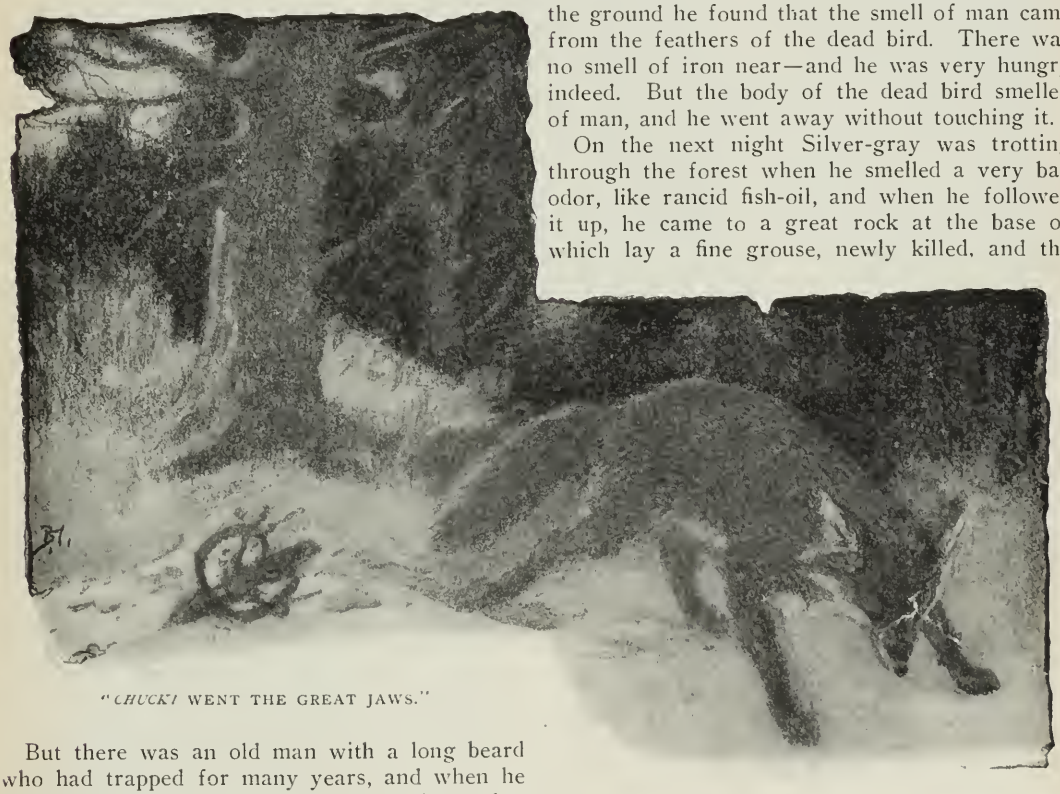
Now there were in California many men who had trapped beavers and minks in the days when people liked to wear those furs. And when they heard of the great price offered for the skins of silver-gray foxes they took their heavy steel traps and their rifles and provisions, and climbed to the top of the high mountains which are called Sierra Nevada, that is, Mountains of Snow. There, when the snow lay heavy on the ground and Silver-gray's fur was fine and long, they set their traps to catch him. But while they caught many of his cousins, the black foxes and cross-foxes, and also many of his own brothers, the silver-grays, they did not catch Silver-gray himself—because he knew all about traps.

No matter how carefully they buried their steel traps in the snow, Silver-gray knew where they were. He could smell the iron, and the touch of their hands, and even where their shoes had trodden the ground. For days after they had set them, when the scent had died out in the cold air, Silver-gray could still smell the iron of the traps; and he kept away.

When the spring came and Silver-gray shed his winter fur, all the trappers went down to the valley, for they did not want his skin unless

it was covered with the heavy hair which grew when the weather was cold.

Next winter, as soon as the snow lay deep on the Sierra Nevada Mountains and Silver-gray's skin was once more covered with fine long fur, all the trappers came back to their cabins in the mountains and set their traps again. For so beautiful was the fur of silver-gray foxes that every lady in the land wanted a skin, but the silver-gray foxes were so scarce that the great price of the year before had been doubled.



"*CHUCK!* WENT THE GREAT JAWS."

But there was an old man with a long beard who had trapped for many years, and when he saw Silver-gray's track in the snow he knew that the fox's skin was worth a great price. So, while the other trappers left the mountains, he remained behind; for he had resolved to catch Silver-gray, if it took all winter.

Now, first, in order to make Silver-gray tame and less afraid of the smell of man, this old trapper, whose name was Ransome, went out and shot wild pigeons and grouse and threw them in the places where he intended to set his traps. But Silver-gray passed by without eating them, for he remembered the terrible steel traps and was afraid of the smell of man. Then Old Man Ransome took some medicine which smells very sweet, and is called oil of bergamot, and he rubbed this on the trunks of the trees beneath which he had put the wild birds.

As Silver-gray was coming through the forest one night he smelled a very sweet odor, and when he followed up the wind he came to a pine-tree beneath which was the body of a wild pigeon fresh killed lying upon the ground. The scent of the sweet odor made Silver-gray's mouth water. He was very hungry, but, as he stooped to eat the pigeon, he caught the smell of man.

Then Silver-gray raised his nose quickly from the choice morsels, and when he snuffed about the ground he found that the smell of man came from the feathers of the dead bird. There was no smell of iron near—and he was very hungry indeed. But the body of the dead bird smelled of man, and he went away without touching it.

On the next night Silver-gray was trotting through the forest when he smelled a very bad odor, like rancid fish-oil, and when he followed it up, he came to a great rock at the base of which lay a fine grouse, newly killed, and the fresh meat lay all bloody before him. So rank was the odor of fish-oil that Silver-gray did not catch the smell of man in the feathers, and in a twinkling he devoured the whole bird. But as he trotted along the trail he scented the odor of man.

Until that time Silver-gray had always avoided the trails of men; but now that he was no longer hungry, he was lazy, and he wondered where the man was going. Besides, this track smelled only a little of man, and all the rest was like fish-oil, for Old Man Ransome had rubbed the oil on his shoes. So Silver-gray followed along the trail until he crossed another strange odor, better than

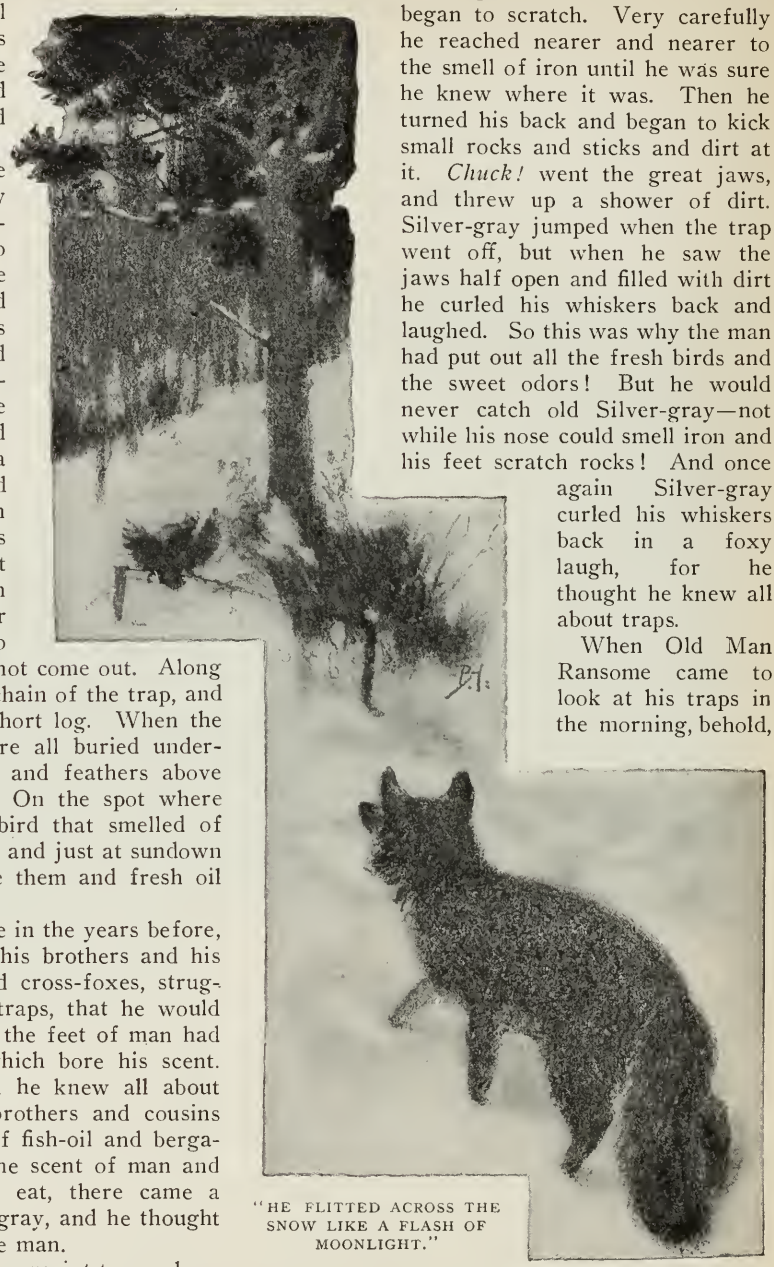
any he had known, and he came to a tree where a fresh bird lay dead on the ground. The sweet smell of anise, dearest of all odors to a fox, came from its feathers; and, forgetting the scent of man, he mouthed and played with the dead bird a long time.

When the old trapper came by in the morning, and saw by the tracks what Silver-gray had done, he laughed to himself—thinking that he would soon catch him—and hastened off to bring his traps. Deep in the ground at the place where Silver-gray had eaten the grouse he dug a hole for his trap, and a trench from there to a short log, which he had buried in the ground. Then he pried open the great jaws of the trap and placed it carefully in the hole, with a piece of brown paper stretched over the top, so that the smell of iron could not come out. Along the trench he stretched the chain of the trap, and then he fastened it to the short log. When the trap and log and chain were all buried underground, he scattered leaves and feathers above the place, and went away. On the spot where Silver-gray had killed the bird that smelled of anise he buried another trap, and just at sundown he placed fresh birds beside them and fresh oil upon the trees.

Now there had been a time in the years before, when Silver-gray had seen his brothers and his cousins, the black foxes and cross-foxes, struggling in the jaws of steel traps, that he would never walk in a path where the feet of man had trod, nor touch anything which bore his scent. Those were the days when he knew all about traps. But now that his brothers and cousins were gone, and the odors of fish-oil and bergamot and anise covered up the scent of man and led him to good things to eat, there came a change in the life of Silver-gray, and he thought that he was smarter than the man.

So when he came to the bergamot-tree, where the man had thrown out a fresh pigeon and the air was filled with the sweet odor of the oil, he did not turn away, even when he caught the smell of iron, the scent of the terrible steel traps, but stopped and swung his head craftily. Pressing his nose to the ground, he snuffed about in a great circle, clear around the tree. This he did to find where the trap was buried—and then he began to scratch. Very carefully he reached nearer and nearer to the smell of iron until he was sure he knew where it was. Then he turned his back and began to kick small rocks and sticks and dirt at it. *Chuck!* went the great jaws, and threw up a shower of dirt. Silver-gray jumped when the trap went off, but when he saw the jaws half open and filled with dirt he curled his whiskers back and laughed. So this was why the man had put out all the fresh birds and the sweet odors! But he would never catch old Silver-gray—not while his nose could smell iron and his feet scratch rocks! And once again Silver-gray curled his whiskers back in a foxy laugh, for he thought he knew all about traps.

When Old Man Ransome came to look at his traps in the morning, behold,



"HE FLITTED ACROSS THE SNOW LIKE A FLASH OF MOONLIGHT."

each was sprung and filled with sticks and stones—and all the birds were gone. Then the old trapper scratched his head and sat down on a log and thought a long time what he would better do. At last he went back to his cabin and brought three more steel traps, and instead of one trap he set two

under each tree, and he covered them yet more carefully. But in the morning all his traps were sprung again, and he saw where Silver-gray had scratched and scratched until he had come close up to them, and then kicked them full of sticks and stones. All three of the birds were gone again, and he saw that Silver-gray was still too smart for him.

On the next night Silver-gray came again and cautiously prowled and snuffed about—and this time he found that the man had set *three* traps at each place.

Curling back his whiskers in a scornful laugh, Silver-gray kicked them all full of stones; and when he had eaten the birds he dragged the three traps together and threw rubbish over them, to show the man how he disdained them.

But on the next night he found the traps all set again, the fresh birds and the sweet smells all there. And though once more he dragged them all into a pile to show his derision, on the night after that there were birds again awaiting his arrival.

Night after night, no matter how often he robbed them of bait, he always found the traps the same; yet each time he scratched about just as warily, for he knew that the man was full of tricks and all the time was trying to catch him.

For a month, with all his patience and skill, Old Ransome tried to catch Silver-gray—but every trick failed. No matter how carefully he buried the traps, no matter how craftily he shifted them about, Silver-gray was always on the watch, and his cunning never failed. Old Ransome hid little traps out in the rocks; he buried them under the sticks and in the dirt, where Silver-gray went for rubbish to kick over the big traps; he concealed them in all the little paths that Silver-gray had made. He even spent days following the tracks in the snow and seeking for Silver-gray's den.

But, despite his skill and patience, in all things the fox was too cunning for him. If traps were set in his path he turned aside and ran up over the rocks. Never did he come in by the same trail twice.

"ONCE MORE HE DRAGGED THEM ALL INTO A PILE TO SHOW HIS DERISION."

When the man hunted for his den he hid in the heavy underbrush, where only a fox could crawl. And every time that he fooled the man his whiskers would curl back as he laughed. But one night he laughed too soon.

To catch the grouse with which he baited his steel traps Old Ransome had set snares on the mountain-side, and one night it happened that Silver-gray passed by the place and heard a bird fluttering in the snare. In a moment all his savage instincts were aroused. He flitted across the snow like a flash of moonlight, and, with a great leap, seized it by the neck. Mumbling and snarling, he devoured the poor bird. Then he sat down and curled his whiskers in a laugh; and that night he did not even visit the anise-tree.

In the morning, when Old Ransome looked at his steel traps, his face fell, for Silver-gray had

not been near them, and he feared that he had gone away. But when he went down to his grouse snares, and saw where the fox had rushed in and devoured the bird, he was glad. A new idea came to him, and he chuckled and laughed to himself. Then beneath a fallen log, where the water had washed out a little channel just large enough for a fox to crawl through, he buried a steel trap ever so carefully, and he left it there two days, so that all the scent of his hands would die away.

On the third day he caught a grouse and tied it by the leg under the log, a little way back from the trap—and he tied it in such a way that it would flutter and be more certain to attract attention. It was a cruel thing to do, but the old man wanted to catch Silver-gray, and he was willing to do anything if he could only fool him.

It was all silent in the great mountains when Silver-gray, the old fox, trotted out across the white snow that glistened in the moonlight and passed along the hillside where the snares were set for grouse. It was a great joke to catch the trapper's birds before he could use them for bait; and at the thought of the tender bird that he had eaten, old Silver-gray turned aside and went up to the snares. A sudden wind roared through the swaying tops of the black pine-trees, and he stopped to listen. Silver-gray did not know it, but the wind was singing a warning song. He was about to be caught.

There was nothing in the snares—yet, as he listened, he seemed to hear, even above the moaning of wind in the trees, a faint flutter—the flutter of wings. Alert, he stood there with the moonlight shining on his beautiful fur, and he pricked his ears to catch the sound.

Whks, whks, it whispered very faintly—but it came from the log on the hill. Eagerly the wily fox crouched down and glided silently toward it; then, with one foot raised, he stopped and listened, snuffing the air ever so lightly.

Whks, whks, whispered the wings again, soft as the rustle of a mouse.

Then *Whrr!* and *Whrr!* in a storm of anguished fluttering, for the grouse had heard his step and knew that he was coming.

Sngrr! snarled Silver-gray, and rushed toward it.

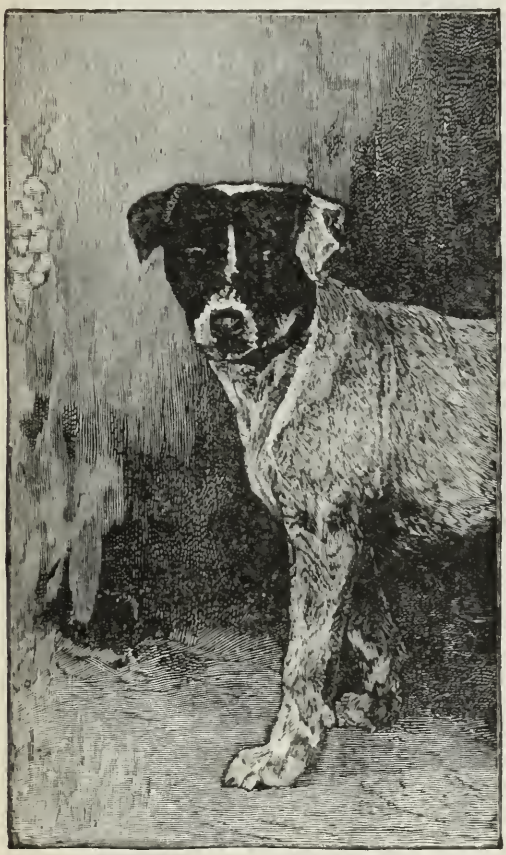
Chuck! went the steel trap beneath him, and the strong jaws seized his foot in a grip that nipped like death. Bite and struggle as he would, the cruel iron, the iron which smelled of man and had once been his deadly fear, still clutched him by the leg—and only the hands of man could make it loose its hold.

With the cold body of the grouse beside him, Silver-gray lay moaning and snarling, while he waited for his captor to come. But even in his agony he bowed his head in shame, to think that he was caught. He had pitted his cunning against the cunning of Old Ransome—and now, in the grip of icy steel, he had learned the last thing about traps.

THE STORY OF A LOST DOG

BY EDITH EVELYN BIGELOW

THERE is nothing sadder or more desolate than to be a stray dog in a great city like London. You may think *you* have seen trouble and been miserable; but listen to me, and you 'll soon see that your trials have been nothing to mine. There never was a more pampered pet than I was; and I thought I had a right to be spoiled, being a thoroughbred fox terrier of perfect pedigree and



THE LOST DOG TELLS HIS STORY.

good habits. I had no faults except yielding to a strong temptation to nip the cat a little when she put her back up at me. I was owned by the prettiest lady in London, and was exercised every day by either the footman or my mistress herself, with a sharp eye kept on me, lest any of those wicked dog-stealers should whip me up, and run off with me.

My only sorrow was, that I could not always make myself understood. Why parrots and magpies (horrid things!) should be gifted in the conversational line above their betters, I can't imagine.

Mag would sit in her cage and croak, "Wake up!" as distinctly as a human being could speak; and my mistress would laugh and say, "Is n't she clever?" But when I barked and thought I was saying real words (only she could n't understand), she would cry, "Be quiet!" and give me a tap on the ear. That seemed unjust to me.

One day in summer, my mistress came downstairs, with her coat and hat on, and took me up in her arms and kissed me. I licked her face and wagged my tail, thinking I was going for a drive, for I saw the brougham standing at the door. But she dropped a tear on my head, and said:

"Oh, John, I can't bear to leave him!"

Then Master said, "Nonsense, my dear, the cook will look after him." And they went away, my dear mistress looking back and saying, "Be a good dog till I come home!"

All this took me by surprise, and I felt very miserable. The tears came to my eyes, and I turned away for fear that hateful cat should see me crying; for if she had, she might have plucked up heart to scratch me in return for all my sly nips.

Well, I lay for some time thinking how lonely I should be with only old Mouser (that was Mrs. Puss's name) and cook, both of whom I hated. Presently I decided to start off when no one was looking, and follow my mistress. I was younger and more foolish then than now, and did not consider what a large place London was. I had a keen nose, and thought I could track my lady, with the help of my eyes and nose.

So I waited my chance. Presently the parlor-maid came downstairs. She opened the door, and before she could say "knife!" I was off like a shot, down the street. She called after me like a crazy person, but nobody minded her, and I ran till my breath was nearly gone. Then I sat down and rested awhile. But a man with a dirty neckerchief on, and a bad eye, came sidling up to me, and said, "Come here, sir," in a soft, enticing voice. I knew he was a dog-stealer; for I had seen his like before; so I scuttled off again, and in my fright forgot to notice which way I went.

Then I began to look and nose about. I could find no lady who had a face like that of my dear

mistress. People looked at me; the ladies said, "What a dear little fox terrier!" and one gentleman stopped and bent down to see if I had a collar on. When I ran out I had just been washed, and so I had left it at home. Presently I got into a part of the town where there were lots of pale little children playing and fighting on the sidewalk. Some horrid boys pursued me, and tried to fasten an old tin kettle to my tail; then when I ran all the faster, they shouted "Mad dog!" and a policeman—or, as we say, a "bobby" —commenced to chase me. My poor heart beat so, I thought I should have died; but I struggled along, though, being a pet house-dog, I was n't in good running condition, and had rather too much fat on my ribs for a race. I gave the "bobby" the slip, after all, and at last hid under an archway. By this time it was growing dark, and I began to be hungry and lonely.

If the cat had been there, I would n't have nipped her! It is wonderful how misfortune softens the heart! Can you imagine how miserable I was? My nice coat was all torn and soiled, and the several frights I had had were enough to tire even an experienced dog, not to mention the running in and out among hansom cabs. I could not help whining quietly to myself. After a time, one of the figures hurrying by stopped and came up to me. It was a man, and I should say a gentleman, for, as near as I could see in the dusk, he was dressed like Master.

"Hullo!" said he. "What have we here?"

He stooped and picked me up. His touch was so kind that I did n't even growl.

"A lost dog! A case for the Battersea Home," he exclaimed.

Now, I had heard cook tell dreadful things about "Homes" and "Institutions," and when I heard my new acquaintance speak of a Home, I gave a growl and tried to get away; but the gentleman was strong, and carried me off with him. He hailed a cab and got in, still holding me. After driving for some time we stopped, and my friend (or enemy, I did n't yet know which he might be) took me into a house, evidently his own. As soon as we were inside the hall, a funny fat little boy with curls came tumbling out of the nearest room shouting, "Here 's father, wid a doggy!" and began to pull me about. As he did n't hurt me, and seemed pleased to see me, I licked his fat little hand, and he screamed with glee. Then a tall lady joined us and asked where I had come from.

"I found him in Fleet street," said the gentleman, "and to-morrow I shall take him to Battersea. He 's evidently a valuable dog, and must have strayed away from his owners. If they don't claim him—I 'll buy him for you if you like."

"The very thing!' said the lady. "See how Totty is petting him."

Then I was taken upstairs into the drawing-room, and allowed to sit on a rug. The lady kindly gave me some water, and I felt very much happier since I had heard that nothing terrible was to happen to me; besides, it was very comforting to be recognized as a valuable dog. I was so tired that I slept for a long time; in fact, it was morning when I awoke. My new friends gave me some breakfast, and the gentleman started out with me again in a cab. We drove a long way this time, to a very ugly part of the town, where everything was grimy and dirty and ever so many trains were whizzing along across bridges built over the street.

We drew up at a queer sort of place, with a door like the gate of a stable-yard, and a small door next it, on which was a brass plate. On it I read—for I am an educated dog, let me tell you, and am sorry for those who have n't had my advantages—"Home for Lost Dogs." We went in through the big gate, but turned to the side and entered by a small door into a room where two men sat, one at a desk and the other at a large table. My gentleman spoke a few words to the men, and presently left me with them. Then another man came in. He was very tall, dressed in black, with a cap on his head and a big whip in his hand. His face was kind, and so he did not frighten me. He carried me away and walked with me down a place, on one side of which was a line of cages full of all sorts of dogs. Some of them were ill-bred, vulgar creatures, especially a low, bandy-legged bulldog, who jeered at me and called me names. I was placed in a cage with a poodle, a fox terrier, two pugs, and a dachshund—the last about a yard long, with no legs to speak of, but a great opinion of himself. They all set up a roar when I arrived, and asked me a lot of questions—who I was, where I came from, and the like. I was very haughty with them at first, wishing to show my breeding, for I remembered how a lady, who cook said was a duchess, always behaved to my mistress when she called. But they were so good-natured that I soon forgot to be proud, for I was full of curiosity about my new home, and wanted to ask questions.

"I am going to be bought," said I, "if my people don't come for me."

The pug shook his head, and gave a sort of snort. Pugs always are short of breath.

"Don't be too sure!" said he, with his black nose in the air, and his great goggle eyes turned toward me. His remark was so rude that I

turned my back on him. The poodle sidled up to me and whispered: "We 'll all be killed in three days, if we 're not sent for!" I gave a yelp of horror.

"My goodness!" said I, "what do you mean?"

"There 's one terrible room here," said he; "*if a dog once goes into it, he never comes out alive.*"

At that I turned quite ill. Had I come all this way, only to be butchered?

"How do you know?" I gasped.

"The cats told me."

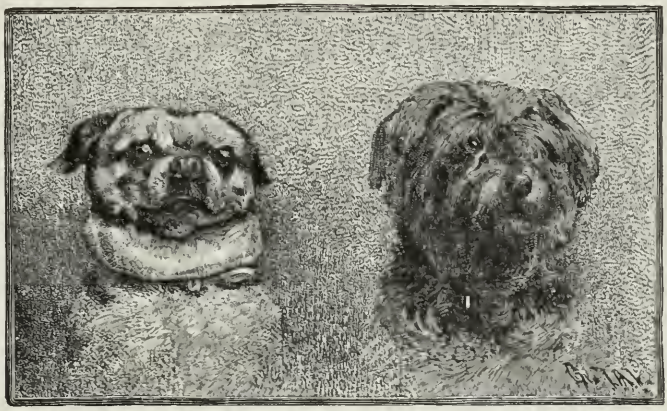
"What cats?"

"Do you see that door? That 's where the smart nip on the ear. Then there *was* a row! We were in one great mass, struggling and biting, till the keeper's whip came cutting in among us, and we were forced to be quiet.

That night the door of the Cats' Boarding-house and Home was left open by mistake, and while I lay, trying to sleep, I heard a little "mew" which sounded familiar. I gave a little whine in reply, thinking I should find out whether I had a friend among the pussies.

"Who are you?" I asked, softly.

A little voice mewed out, "Don't you remember the fat kitten next door?"



TWO INMATES OF THE BATTERSEA HOME.

Cats' Boarding-house and Home is; and last night when the door was open one of the boarders told me. *She* had it from the keeper. Perhaps you 'll be kept longer than the usual time, as you are a good sort; but I 'm a mongrel and must die to-morrow."

He gave a patient sigh, as if he had made up his mind to it. "You are very quiet about it," I said; "I should yell all to-day if I expected to be killed to-morrow."

"Yelling would do no good," he replied. "I should be called to order now, and killed just the same, when the time came. The truth is, I have been so ill-treated that I 'd rather die than go back to my master. I am not much to look at, but I can do all manner of tricks, and I traveled with a circus. My master was the clown, and was what human beings call a *brute,* though why they shame *us* by giving wicked people that name, I can't think."

The poor poodle felt so sad that I did n't know what to say to him; for how could I comfort him?

Just then the dachshund looked around and said, "I wish that cur would stop that sniveling. I can't hear myself think."

With that I jumped at him and gave him a

"Yes, indeed!" I said; for, indeed, that kitten had been the only cat I had ever really approved of.

"I was whipped for stealing cream, and I ran away. Oh, how many times I 've wished myself at home!"

"Have you suffered?" I asked.

"Suffered?" said she. "I am as thin as a mouse, and supported here by what visitors throw into the box that 's fastened to our cage; and there 's a little fiendish black tabby here that gets all my food away."

"Poor thing!" I said, my heart feeling very heavy.

"Never mind," said she, plaintively. "We 'll all be killed day after to-morrow."

The same old story! "Tell me all about it," I said.

"There is a room here where the dogs and cats are put, and as soon as they get in they begin to snore, and never wake up."

I could n't help shivering at these words, for it is an awful thing to lie in the dark and think of your own death. The man who keeps order in the cat-house heard us talking, and shut the door; so I learned no more that night.

The next day the poodle came up to me, and cried, and kissed me on the nose, saying I had been kind to him, and he wanted to thank me before he died.

I tried to cheer him a bit, when, suddenly, two ladies came walking by.

"Stand up and beg," I whispered. And so he did.

"What a jolly poodle!" said one lady. "The very thing for Charlie. Is he for sale?"

The keeper, who stood near, said:

"He was to be killed to-day, madam, but you can have him."

In a few minutes more my fortunate friend was taken out of the cage and carried off, no doubt to as comfortable a home as the one which I had left.

Nobody came for the pugs or the dachshund; but, toward evening, whom should I see but cook, with her jolly red face, coming along and looking anxiously at all the dogs.

I barked as loud as possible, and says cook, "That 's him!" Cook was apt to be rather ungrammatical at times. When they got me out of the cage, I licked her face, as if I 'd loved her all my life. She was so pleased to see me that she kissed my head and patted me all the time.

"Now, Mr. Keeper," said she, "there 's a kitten missing from our next-door neighbor's, and it 's just possible she 's in the cat-house, so I 'll take a glance, if you 're agreeable."

Then I was glad, for I did n't relish the idea of leaving the only well-behaved cat of my acquaintance to be made away with, and nobody the wiser. In we went, and the poor kitten saw cook and flew at the cage, trying to get to her. There were a number of cats with her, and the label over the top said "Female Strays." The boarders were on the other side of the room. Their masters and mistresses had sent them there to be kept safely during their absence from town.

Well, we had the kitten out in no time, and she and cook and I all went home together. Cook talked to us all the way, as if we understood her —and so we did, only she did n't know it.

That is the end of my trials; but I suffered enough in a day or two to last some time.

Since then I have never left my happy home, except in the care of some one. Sometimes in the dark, I can't help thinking about that room where the poor pugs and the dachshund must have died, and the thought makes my paws cold.

But the poodle is happy. I saw him last week driving in a carriage.

LINING UP FOR THE RACE.

LISTENING TO BEASTS AND BIRDS

PART II

WILD BOAR

Long, long ago Wild Boars lived in the forests of England. In the days of William the Conqueror any common man that killed a Boar was punished; only the King and the great nobles were allowed to hunt such beasts. But when men began to build great cities, the forests had to be cut down to make more room, and the Boars and Stags and Wolves and other wild beasts were hunted and killed until there were none left in England. Nowadays you would go to North Africa or Asia or some part of Europe if you wanted to hunt the Boar, but it is a very dangerous and difficult thing to do. The Wild Boar's tusks are very sharp; he is very strong, can run very fast, and is never afraid. Neither tigers nor elephants nor horses nor men can ever make a Boar turn coward, even when he is wounded to death.

Once upon a time three Wild Boars met in a forest. Said the First Boar, "Brothers, last night I dreamed a dream!"

"About eating roots and plants, I know," grunted the Second Boar. He was very greedy.

"About trampling down crops and tearing up the vines, I dare say," said the Third Boar. He was very mischievous.

The First Boar pushed his snout into the ground and dug up a root.

"I dreamed," he said, "that I was shut up in a queer little house. I had grown very, very fat and had lost my sharp canine teeth, that is to say, my tusks. My skin was as thick as ever, but I had not so many bristles as I have now. I could n't run fast, and I did not care for anything except eating and drinking and sleeping. Soon a man came along and gave me a bucketful of stuff which he called 'pig-wash.' 'There,' he said, 'that will fatten you up, piggie. We shall have some fine pork and ham from you this year and the goodwife will make us as much lard from your fat as will last us a twelvemonth.'"

"Did you rush at him and rip him in two?" asked the Second Boar.

"I tell you I had lost nearly all my tusks," grunted the First Boar, stamping the ground angrily with his cloven hoof. "I was changed from a fierce Wild Boar into a tame pig, and, my brothers, that is what will happen to many of our race some day." And he was quite right, for if the Wild Boars had not once upon a time been tamed, there would be no fine fat pigs going to market now.

HIPPOPOTAMUS

"You can come nearer, I won't hurt you," said the Hippopotamus, looking at me kindly with his little bulging eyes that fit into a hard bone socket. He was wallowing about in a big tank at the Zoo, for the Hippopotamus spends most of his time in the water. "See how long I can stay at the bottom," he said, and down he sank under the water, and there he stayed for quite ten minutes. Then, just when I had made up my mind not to wait any longer, up he came again, spouting water out of his nostrils like a whale. "If I were at home in Africa," he remarked, "I would show you that I can walk as quickly along the bottom of a river as I can on dry land. That is why I am called a Hippopotamus, which means a river-horse, you know."

"You look more like a river-pig," I said, and hoped he would not be cross. But he was. "The Hippopotamus may look like a pig," he snorted, "but he is not a pig. We are a family quite by ourselves. The pigs have cloven feet, but my four toes are shorter and partly webbed. And there is all the difference in the world between a pig's snout, with its disk at the end, and mine." Here he snorted again, rolled his big barrel of a body about in the water and opened his mouth for me to see. Oh, what a big red cave it looked! In the lower jaw are two huge canine or tearing teeth like tusks, curving backward. Between

these two tusks are two smaller incisor or cutting teeth and they point forward.

"I see you admire my teeth," said the Hippopotamus. "Well! I admire them myself. At home in Africa I use them to root up the lotus, papyrus, and other water-plants which are my food. My teeth are made of very hard ivory which never turns yellow, and that is more than the Elephant can say about his tusks.

"Is it true that in Africa your brothers do a great deal of harm in the fields?" I asked.

"We like to eat the maize and the millet and the sugar-cane," was the answer. "And if we happen to find a fine crop we trample it down and eat it—we can eat a great deal you know—and that is why the natives hunt us and set traps for us. They make whips out of our hides and they eat our flesh"; and the Hippopotamus sighed and looked very sad indeed. "Good-by," he snorted. "Tell the children that a baby Hippopotamus is carried about on its mother's back." So saying he sank down again to the bottom of the tank.

RHINOCEROS

The Rhinoceros had been for a swim in the river, after which he went to roll in the mud, for the insects were biting him badly that day. You would never think that a beast with such a very thick tough skin would be worried by insects, but he is. If you look, you will see that his queer-looking hide is doubled into folds, and between these folds the insects creep. They know that the skin inside is very tender. To keep them out the Rhinoceros cakes himself over with mud. As long as he stands quite still it is all right, but the moment he moves the cake of mud cracks, and the insects begin to bite him again.

After his mud-bath the Rhinoceros thought that he would like something to eat, so he lumbered into the jungle, pushing aside the long grass with the queer horn on his nose. As he went, some birds flew down from the trees and settled on his back. Mr. Rhinoceros did not mind; he was used to them, and indeed he was very glad, for the birds came to eat the insects.

"I am an odd-toed beast! I have only three toes!" he mumbled to himself.

"Mind where you are going, please!" piped one of the birds. "I was knocked off by a hanging branch just now!"

"You must look after yourself," grunted the huge beast. He was an Indian Rhinoceros. If he had been an African beast, he would have had two horns, one behind the other on his nose. "You can fly on again, I suppose, if you tumble off," he said. "And you may think yourself lucky to be allowed to ride on my back. Next to the Elephant I am the biggest animal in the world. Even the Tiger is afraid to attack me because of my strong horn, and my thick skin which his claws cannot hurt!"

"It is very kind of you indeed," chirped the bird, "to let us stay here, but we make some return for the favor. We eat the insects, and we scream out with fright, and tell you when your enemies are near. You know your little eyes cannot see very far, and if it were not for us you might be taken by surprise."

The Rhinoceros did not answer. He stopped in front of a tree, dug his horn into the root close to the ground and, ripping up the trunk, began to eat the woody fibers and the branches, with the help of his funny under lip. You think perhaps that he hurt his nose ripping up the tree, but he did not. The bone in his nose is arched and very elastic. When the Rhinoceros gives a hard dig with his horn, this bone, which is something like a spring, saves him from jarring his nose and his big head.

INDIAN ELEPHANT

"Hrumph! Hrrumph!" Listen to what the Indian Elephants say about themselves.

"Hrumph! Hrrumph! We are great lords, and our trunks are our hands. We are the biggest animals in the world, and the wisest; the strongest and the most useful of the beasts of burden. In all the great shows and processions in India we walk, stately and proud in our splendid harness, bright with jewels and gold, and if you think that we make much noise when we march you are mistaken. Swish! Flop! Swish! softly and quickly we go, and proud is the prince who can go a-hunting with a hundred elephants in his train.

"The white men and the natives call us their friends, and the children love us because we are gentle and good; but let him who ill-treats us beware, for to those who are cruel we are cruel, and to those who are kind we are kind.

"Hrrumph! Hrrrumph! We are great lords, and our trunks are our hands, and our arms, and our noses, and many other things besides. They are made of muscle, and are so strong that with them we can pull up young trees by their roots, and with the little thing at the end, which is something like a finger and a thumb, we strip the leaves from the branches, and pick the flowers and the green food which we eat.

"In our trunks, at the end too, are the nostrils, and with these we smell the sweet flowers and

fruits before eating, for above all we love those things that smell sweet. We breathe through our nostrils, and through them we draw up the water to pour into our mouths when we are thirsty. Inside our bodies, in our stomachs, is a well which holds water, and in summer, when the streams run dry, all we have to do is to put our trunks into our mouths, suck up the water from the well, and squirt it over our bodies, for we love to bathe.

"With our beautiful strong ivory tusks, which grow longer as we grow older, we defend ourselves from our enemies—from the lions and the tigers and the fierce jungle-beasts. With our tusks, too, we carry heavy planks of wood for our masters, when they build, and after we are dead our tusks are made into pretty ornaments.

"Hrrrumph! Hrrrrumph! We are great lords, and our king is the white elephant who lives at the court of the King of Siam, in a splendid house with a hundred men to wait upon him, and to feed him out of golden dishes."

AFRICAN ELEPHANT

"The children want to know something about you," I said to the African Elephant, when I saw him in the Animal Gardens.

"Hrrumph! Hrrrumph! I am a great lord, and——"

"They know that already," I said quickly. "Would you mind opening your mouth wide so that I may see your teeth?"

"You might throw in a bun at the same time," said he, and I threw in the bun.

Elephants have twenty-four teeth, six on each of their top jaws, and six on each bottom jaw. These great teeth are made up of three things—enamel, ivory, and cement. The cement wears away first and leaves ridges across the teeth, so that Mr. Jumbo can grind his food easily.

When he was tired of keeping his great cave of a mouth open the Elephant shut it and said: "If you give me another bun, I will tell you something funny about my teeth. Hrrumph! thank you! Now look at this first tooth, the only one you can see. It has four ridges. In time it will wear quite away, and the second tooth, which is bigger still and has eight ridges, will push forward to take its place; when that has gone, it will be the third tooth's turn, and so it goes on in the same way, until the last and biggest of all is in the front. But this happens so slowly that my twenty-four teeth will last me all my life, and I suppose, like most of my brothers, I shall live long."

"What is the difference between the teeth of an African and those of an Indian Elephant?" I asked.

"My sixth tooth has only ten ridges, but my Indian brother has twenty-three or twenty-four ridges on his. Still his ears are not half so big or so fine as mine." Here he flopped his ears up and down, and then wiped his eyes with them. After this he snorted: "I had better tell you that my back is hollowed out a little, and that I have only three toes on each hind foot. The Indian Elephants have four, but I think that we Africans have a keener sense of smell."

This said, he gave a kind of snorting sigh, as if to say: "How I should like to run wild in Africa again, although the natives do hunt us for our tusks and eat our flesh. We elephants live so happily together in herds, and in times of danger the big always help the little, and the strong defend the weak, but we hurt no one unless we are attacked."

After this he would not speak any more, but when I had given him several buns, "Hrrumph! Hrrrumph!" he trumpeted. I suppose he meant, "Thank you!" "Hrrumph! You may bring me a young tree next time you come."

HORSE AND ASS

"Play while you can!" brayed the Ass to the Foal as he frisked round about his mother, the Mare. "You will not run free all your life!"

The Foal stood still. "Why not?" he whinnied.

"Because you will draw Master's carriage one day, and then you will have to work," was the answer.

"Do you work, Mother?" asked the Foal.

"Of course I do," answered the Mare, "but you must not listen to the Ass, my son; he has bad manners."

"Hee-haw! Hee-haw!" laughed the Ass. "Don't despise your own family!"

"It is true," said the Mare, "that you belong to the Horse family. Your teeth are made to grind, and you have only one toe in your hoof, but all the same you are a much coarser kind of beast than I. You eat thistles and grasses, which a horse would never touch; your skin is thicker, your hair is coarser, your mouth is harder than mine. You cannot run so fast, nor draw such heavy loads, and altogether you are neither so good-tempered nor so useful as I am."

"That may be," said the Ass, "but you, with your thin skin and tender mouth, are afraid of the whip and the pull of the reins on the bit; while I, if I want a rest, just take it, and never mind the whippings."

"That shows the difference between us," an-

swered the other. "We horses are proud to work for good masters, and we do our best to please them."

"I can work, but I like my own way," said the Ass.

"I like my own way too," whinnied the Foal.

"When you are as old as I am," said the Mare, "you will like nothing better than a good day's work, and a quick run home to a big feed of oats and hay."

The Ass helped himself to a thistle. "In Africa and Asia," he mumbled, "my wild brothers can beat any horse at running, and in some hilly countries we are more useful than you: we are so sure-footed."

"In Arabia, my brothers live in the tents with their masters," answered the Mare. "They are the most beautiful horses in the world, and they can run even faster than an ostrich."

"What is an ostrich?" asked the Foal. His Mother pretended not to hear the question. "Come, we will race to the end of the field," she said, and away they went like the wind. The Ass, having finished the thistle, opened his mouth very wide. "Hee-haw! Hee-haw! She does n't know what an ostrich is!" he brayed, and I think he was right.

ZEBRAS

Although Zebras look very like horses, for they belong to the Horse family, you cannot drive them in a carriage or ride on their backs: they are too wild. But they can be caught and put into a paddock in the Zoo, for grown-up folks and children to see.

The Zebra's real home is in Africa, where it lives happily on the plains, although, as an old Zebra told me, it has to keep well out of the way of the fierce lions. Zebras, you see, like horses, eat green food, and the beasts that eat green food are always in danger of being eaten by the beasts that eat flesh.

"Suppose you were back again in Africa," I said to that same old Zebra, "and suppose it was a bright moonlight night, and you stood still to rest after a long gallop, and suppose while you were standing there, you saw a lion come stalking over the plain, what would you do then?"

"Stand quite still," answered the old Zebra.

"Stand still!" I cried, and so loudly that he gave quite a start. Zebras, like horses, are nervous beasts.

"Of course you think my coat is very beautiful," he said suddenly. "We Zebras are very proud of our elegant stripes—yellow and black for the male, and black and white for the female."

"We all admire your neat shape and beautiful coat," I answered, "but what has your coat to do with the lion?"

"I am coming to that, if you will have patience," he said a little crossly. "Our stripes do not only make us beautiful, but they protect us from our enemies. You may not believe it, but on a bright moonlight night you might be standing quite close to me, and yet you would never see me."

"I am sure I could!" I said.

"Not in Africa," snorted the Zebra. "If I was all white or all black you could, but being striped as I am you could not, for the stripes exactly match the colors of the desert or the plain by moonlight."

"So that is why you are striped!" I said.

"Yes, and that is why I should stand quite still if a lion was close to me," he replied, "for when it comes to fighting, what chance have I against that terrible beast? He has strong claws, I have only hoofs; his teeth are made to tear, mine can only grind. If it were not for our stripes, many more of us would die, and as it is, there are few enough Zebras left now for hunters to take and lions to kill." So saying, the Zebra sighed and trotted to the other end of the paddock.

RABBIT AND HARE

The Rabbit and the Hare could not agree. The Rabbit said that she belonged to the same family as the Hare, and the Hare would not believe it.

"My dear madam," said the Rabbit, "every one knows that I am a Rodent, just as you are."

"Your ears are not so large as mine," answered the Hare, "and if we were to race up-hill, I should certainly reach the top first, because my hind legs are longer than yours."

"My tail turns up like yours," said the Rabbit quickly, "and white tail-tips are as useful to Rabbits as to Hares. What should we do when the dogs attack us suddenly if we could not see the white on our leader's tail? We should not know where to run, or whom to follow."

"That is true," answered the Hare, "but all the same, a white tail-tip does not make you a Rodent. Just think what different houses we have."

"My burrow is more comfortable and much safer than your tuft of grass," said the Rabbit a little angrily. "It has two entrances—a back and a front door. Also I have another burrow for my little ones, with only one door, and you may be sure I take care to cover the hole with a clod of earth when I go out, so that my babies may sleep safely in their cozy nest of dried leaves and fur from my own body."

HOMEWARD BOUND

MR. BUNNIE: "COME, MR. MOLEY, TRY THE ELEVATED ROAD, ONCE.'

MR. MOLEY: "NO, THANK YOU, I PREFER THE SUBWAY FOR SEVERAL REASONS. I CAN SEE SO MUCH BETTER FOR ONE THING."

THE FRETFUL PORCUPINE: "HUH! NOBODY EVER GIVES ME A BOOST!"

"My babies can see when they are born, and yours are blind," said the Hare; "and they have fur to keep them warm, while yours at first have none."

"They are none the worse for that," was the answer, "and they are all Rodents, every one of them."

The Hare shook her long ears. "Why should they be?" she asked.

"Because their teeth and every Rodent's teeth are made to *GNAW*," screamed the Rabbit, quite losing her temper this time. "I can gnaw as well as you can. My front cutting teeth, which men call incisors, are the same as yours. I have no tearing teeth, neither have you, for we do not eat flesh. My cheeks are pouched and so are yours."

"Are your front teeth hard on the outside and softer inside?" asked the Hare timidly.

"They are indeed, and that is what makes them so sharp," answered the Rabbit. "The soft part is always wearing away and growing in again, so that the hard outside edge is kept thin and sharp."

"Well!" said the Hare, "I suppose you are a Rodent after all." As she spoke the wind rustled some dead leaves. In a trice both the timid, quick-eared, quick-footed animals were gone.

FIELD-MOUSE AND BROWN RAT

The Brown Rats, we are told by men who ought to know, went sailing in ships from Asia, or from Russia, to England about 1725. How or when they first got to America nobody seems able to tell. But they are here, and they are in almost every part of the world.

Wicked they look, and wicked they are, the fierce Brown Rats. They are thievish, they are cruel, they are unclean. Their sharp teeth can gnaw through almost anything, and they do not mind what they eat. A wounded rat that cannot defend itself is very often killed and eaten by its cruel comrades. When very hungry, rats will attack a man. They make their home in barns, farmyards, grain stacks, sewers, old houses, the holds of ships, and many other places, and very hard it is to get rid of them when they have made up their minds to stay.

But these filthy little beasts have some very nice relations. The Hares, the Squirrels, the Rabbits are all their cousins, for they belong to the Rodent family. Their teeth are made to gnaw with, their cheeks are slightly pouched, and like all the Rodents their mouths are divided into two parts, two funny little rooms. In the front room are the incisor or cutting teeth, then there is a passage leading to the back part where the molars or grinding teeth are. This division is to save the mouth from being hurt while the animal gnaws.

The pretty little Field-mouse belongs to the same family. There is no need to tell you about their teeth and their mouths, as you already know something about the Rodents. What is that queer round thing that looks a little like a baseball hanging to the corn-stalk? Can you guess? Of course you know that it is the nest.

I wonder if you could plait split leaves into a hollow ball as easily as wee Madam Field-mouse does every summer. It is so firmly made that it can be rolled along the ground quite a long way, and it will not break. And there, inside this ball, the tiny blind mice stay, safe in their nursery, until their eyes open and they are big enough to start life for themselves. Where is the door? How does the mother mouse walk in and out? No one knows, except mother mouse herself, and she will never tell, for she wants to keep her little ones safe from harm.

SQUIRRELS

If you were a little Squirrel you would have to be very busy indeed. You would have time to climb the trees and have jumping-matches with the other Squirrels of course, but all the same you would have a great deal of work to do in the summer and the autumn. You would be up bright and early at sunrise, and all day you would gather nuts, buds, and beech-mast, for winter is long and cold, and if you did not lay in a good store of food beforehand, you might die of hunger.

And where would you put all the food that you gathered? Ah! if you were a wise little Squirrel you would never tell me that. You would say, "That is my secret!" and when I was not looking, away you would leap, whisking your pretty long tail, and I should never be able to find the hiding-hole. You would always be able to find it, even if it were covered up with snow—that is to say, if you were a Squirrel and not a little girl or boy.

Although Squirrels choose a sheltered nook, and go to sleep there during the winter, they often wake up hungry and want a meal. Then they bustle off to their secret store to dine, returning again to their shelter to sleep, or perhaps to sit and think about the spring, and wish the warm weather would come. When the warmer weather does come, then it is time to make the nests for the baby Squirrels. Have you ever seen a Squirrel's nest? It is woven of twigs, and lined softly with leaves and moss, and it has a roof of leaves to keep out the rain. Such a cozy little house it is, perched on the forked branch of

a tree, or snugly built in a hole high up in the trunk, all ready for the babies when they come—wee Rodents, every one of them.

Besides having, like all the Rodents, cutting teeth made to gnaw with, and funny-shaped mouths, Squirrels have feet that help them to leap and to climb. Each hind foot has five long toes; the middle three are the longest, and these three, being equal in length, give great power to jump. Behind each toe is a woolly pad. These pads save the wee beast from hurting itself if it falls, or jumps on to a hard rough place. Muffs and collars are made from Squirrel's fur. The Siberian Squirrel has a lovely coat of a gray-blue color. It is the prettiest of all Squirrels, and to buy its fur costs a great deal of money.

HEDGEHOG AND PORCUPINE

"Are you a bigger me?" squeaked the Hedgehog, the first time she met a Porcupine. It was in Italy. The Hedgehog lives in some countries—England, for example—where the Porcupine does not. He lives chiefly in the south of France, in Italy, Africa, Asia, and in North and South America. The Porcupine stopped his slow march.

"I simply don't understand you," he said shortly.

"I only asked if you were a bigger me," answered the Hedgehog. The Porcupine tapped the ground angrily with his hind feet. "What kind of a beast is a 'bigger me'?" he asked, and then muttered to himself, "Stupid thing!" The Hedgehog ate up a beetle that happened to cross her path.

"Can you do that?" she squeaked.

"What?" asked the Porcupine.

"Eat insects," answered the Hedgehog. "Ah! that beetle was good!"

The Porcupine was in a rage now. He stamped his hind feet, lifted all the spikes on his head and body, and rustled those in his tail.

"Madam," he said, "I am a Rodent, and my teeth are made to gnaw with. I have bristles and hollow spikes instead of fur, but I am a Rodent all the same, and I eat vegetables and leaves and the bark of trees."

"I beg your pardon," squeaked the Hedgehog politely. "It was your spikes that made me think you might be a bigger kind of Hedgehog, and eat insects and things. You see I have spikes too."

"Fudge!" was all the angry Porcupine could say. I forgot to say that the Hedgehog had not raised her bristles, for she knew there was nothing to fear, but whenever the Porcupine said "Fudge!" she rolled herself into a ball, stuck out her prickles, and lay for all the world like a round pincushion with the pins put in the wrong way. The Porcupine was surprised; indeed, he did not understand that the prickly ball was a Hedgehog. "Where has the stupid thing gone?" he said, for a Porcupine cannot roll himself up like a Hedgehog; all he can do in times of danger is to raise his spikes and try to stick them into his enemy.

"Here I am!" cried the Hedgehog, undoing herself again; "it is a fine thing to be able to turn into a prickly ball. Then any one that touches me gets a sharp mouthful of prickles for his pains. Also I can drop down from a height without being hurt, for my prickles are so elastic."

"Mine defend me from my enemies too," said the Porcupine.

"Mine were quite soft when I was a little blind baby Hedgehog," said the other, but the Porcupine was not listening. "Winter is coming, and I must find a cozy nest and stay there until the spring," he said to himself.

"And so must I," said the Hedgehog. "I begin to feel sleepy already. So good day to you, sir!"

"Good day to you, madam. I am very glad to see you go," answered the Porcupine, who likes his own company best.

GREAT KANGAROO

When you see a Kangaroo in the Zoo for the first time, you say, "What a queer, clumsy creature! It must have been put together by mistake. Its hind legs are too long, its fore legs too short; its head seems too small for its body, and whatever use can there be for such a long, thick tail?" And perhaps, while you are saying this, a baby Kangaroo might pop its head out of its mother's pocket, or pouch as it is called, and then you would certainly burst out laughing, for surely it is a funny thing for a mother beast to keep her baby in a pouch. But if you sailed over the sea to Australia or Tasmania, where the Kangaroos live, and saw them on the plains, hopping about over the brushwood, you would understand why they are made so queerly. Instead of running, they jump. Oh, how far they can jump, and how fast they can go, especially when frightened! Their clumsy hind legs and tail help them to do this. Thud! Bang! Thud! Down goes the tail on the ground. You can hear the thud long before you see the animal. Bang! Thud! Bang! Away leaps the Kangaroo over the bushes, balancing itself with its tail.

When men and dogs go a-hunting the Kangaroo—for its flesh is good to eat, and its soft fur is useful too—the beast has another weapon with

which to defend itself, besides its very strong legs. This is one very sharp and strong claw on each hind foot, and it makes a terrible wound; but the Kangaroo prefers to flee from its enemies, rather than fight with them.

And now I will tell you about the baby Kangaroos. When they are born they are very tiny and very delicate. If they were not kept warm and cozy they would die. So the mother has a pouch, on the under part of her body, something like the breast-pocket in an overcoat. The babies live there until they are about eight months old. Then, if they promise to come back again when tired, they are allowed to hop out and crop the grass, and this goes on till they are strong enough to look after themselves.

When a Great Kangaroo is full-grown, it is about five feet high, measured from the tip of its nose to the beginning of its tail. As for the tail, it is sometimes four feet long. Besides the Great Kangaroo there are many other kinds—some not much bigger than a rabbit, and they all belong to the family of Marsupialia. Marsupialia is a very big word that means "a pouch," and it is the family name of all the pouched animals.

OSTRICHES

The Ostrich had scraped a great big hole in the sand. This was the nest, and inside it she had laid fourteen big eggs. The sun had baked them by day, and the Mother Ostrich had kept them warm at night, for in the great desert of Sahara the nights are cold, and now the fourteen eggs were hatched into fourteen fine little Ostriches.

"What are you going to give them to eat?" asked the Father Ostrich. "We old birds can manage very well in the desert, for we do not mind what we eat. I, for instance, am not at all dainty. A piece of iron, a stone, a stick, any rubbish does for me when there is nothing else, but the young birds have more delicate tastes."

"You have a very bad memory, my dear," said the Mother Ostrich. "You have forgotten that I laid some eggs at the side of the nest, on purpose for the children when they broke their shells, and you know one of our eggs will feed three men."

"Don't talk to me about men," was the answer. "They catch us, take us to their ostrich-farms, and pull out the beautiful black and white feathers in our wings and tails. I hope I shall never be caught. I should not like to see my feathers waving in a hat or a fan." And he gave a cry of disgust. The cry of the Ostrich is more like a lion's roar than anything else.

"We can always run away from the hunters," said the Mother Ostrich. "Even although we cannot fly, our wings help us to run. Dear me, how fast we can run! Not many animals can overtake us, and we are the only birds that have two toes on each foot."

"We can kill a man easily; our legs and wings are so strong," said Father Ostrich; "and we are very fierce too. The Arabs call us the Camel-bird, because our home is in the desert, and they say also that, like the camel, we are very stupid. Now I do not think I am stupid, do you?"

"Is it better to run toward the wind or away from it?" asked the other bird, not answering the question.

"Why, toward the wind, of course," was the answer.

"Even when our enemies are coming that way?" asked the Ostrich Mother.

"Enemies or friends, we must run toward the wind, no matter what may happen," cried the Ostrich.

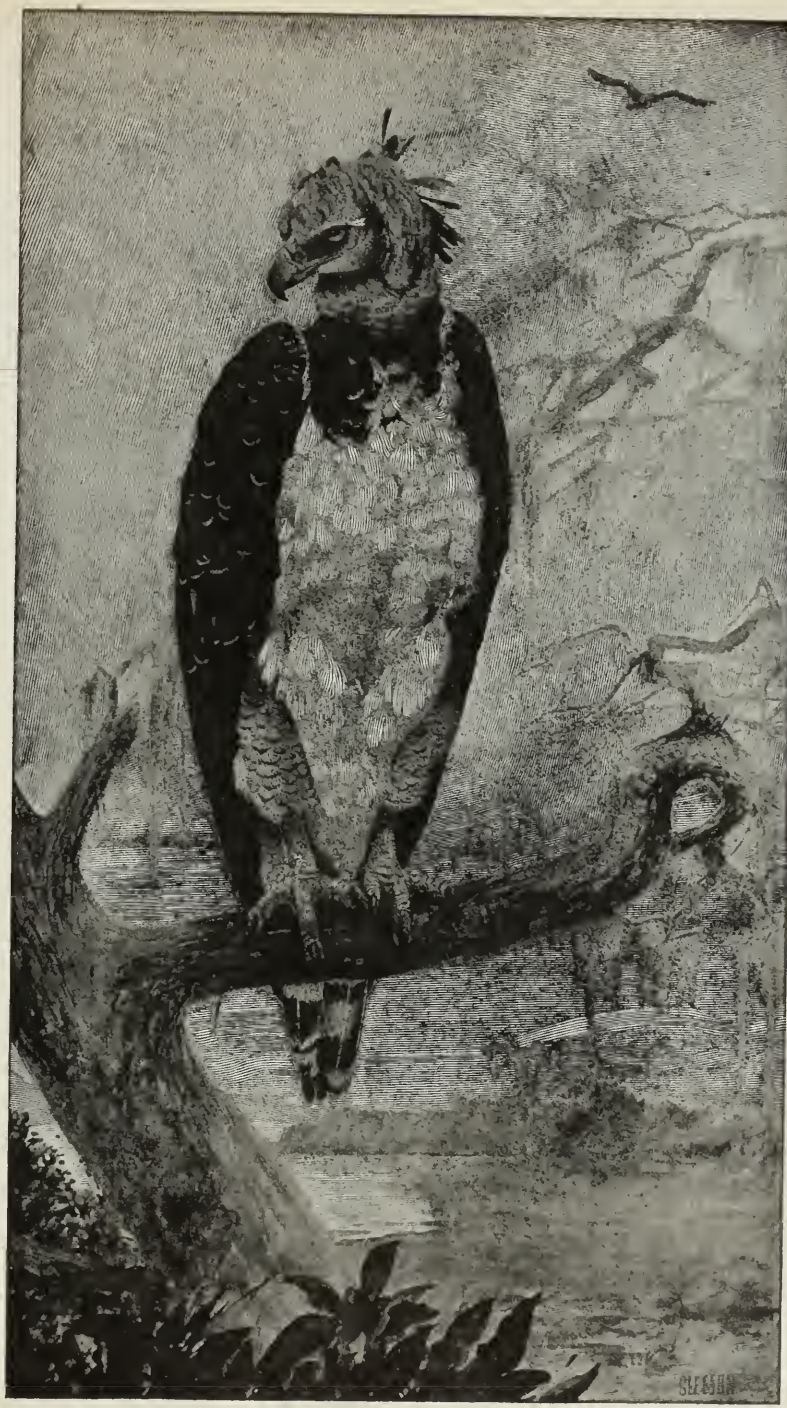
"I quite agree with you," said the other, and neither of them knew that it is because they do this and other things of this kind that the natives think them stupid.

GOLDEN EAGLE

Two Golden Eagles lived together on a high mountain. They had built their aerie—so the Eagle's nest is called—upon the crags. It was made of branches of trees and lined with heather and leaves. There were no other Eagles living on that mountain, because Eagles live only in pairs. Each pair chooses a different mountain, and there the mother bird lays her eggs, only two at a time; and when the Eaglets break the shells the parent birds look after them and feed them until they are old enough to fly away and make another home for themselves.

The Eagle belongs to the Falcon family, and because he is stronger, and can fly higher and see farther than any other bird, he is called the King of the Birds. The Golden Eagle is one of the biggest of the Eagles.

There were two Eaglets in this aerie and they were hungry. "I will soon bring you something to eat," said the Father Eagle, and he spread his great wings and flew up and up toward the sun. He can do this because his wings are so strong, and his eyes are sheltered from the sunlight by thick-growing feathers that look almost like eyebrows. He has a curtain, too, which he can draw over each eye. Up and up he flew, and if you had been standing on the ground below you would scarcely have seen him, so high did he fly. Looking down he saw a sheep. Think what good



THE HARPY EAGLE.

DRAWN FROM LIFE BY J. M. GLEESON

eyes an Eagle must have to see from so far away! Folding his wings he dropped like a stone —down—down—down—straight on to the back of the sheep. With his strong talons he seized the poor beast, killed it, and carried it in his claws back to the nest. The Eagle is cruel, like all birds and beasts of prey, but he is merciful in one way. The beasts and birds which he kills feel no pain. The grip of the Eagle's sharp, curved claws kills them at once, before they even know that they have to die. The Eagle never uses his curved beak to kill.

When the Father Eagle reached the nest he tore the dead beast's flesh into pieces and fed the young Eaglets. After this it was time to give them a lesson in flying. First the two big birds flew round in small circles; the little ones followed. Eagles always fly upward in circles, and each circle that they make is wider and higher than the last. "Round and up higher! Round and up higher!" cried the Eagle, and the Eaglets obeyed him joyfully. At last the mother took them back to the nest for a rest, but the big Golden Eagle, the tireless, strong-winged King of the Birds, still flew up and up toward the sun.

CONDOR AND KING VULTURE

The Condor and the King Vulture must be put into this book, but they really should not be allowed to speak. You see, they are not nice birds, and they might talk about unpleasant things.

Vultures are carnivorous or flesh-eating, but they do not hunt and kill their prey like their cousins the Eagles and the Falcons. Instead, they eat carrion, that is to say they eat the flesh of dead animals. Now you will understand why I did not like to let the Vultures speak, for beasts and birds talk chiefly about their food, and the ways they have of finding it.

"But," said the Condor (for, you see, these birds *will* speak!), a big Vulture with a white ruff round his neck, "you must not make the children dislike us altogether, for we are useful birds." Here he looked so sad that I answered, "You may tell your use," and he at once began:

"All Vultures are scavengers. In the hot countries where we live, if an animal dies its flesh becomes very quickly bad, and if we did not come at once and eat up the carrion, the air would be so unhealthy that people could not live."

"Allow me to speak," interrupted the King Vulture. "I am much handsomer than you."

"Yet I am the biggest of all the Vultures," replied the Condor. "Look at my great wings! I can fly high up above the clouds where the air is so cold that no man could breathe it and live. My home is in the mountains."

"And mine in the forests," said the King Vulture, "where at night I roost on the top of a tree."

"You are both American birds, are you not?" I asked.

"Look at our nostrils!" said the Condor. "All the American Vultures, the Vultures of the West, have holes through their noses, while the Vulture in the East has a nose like other birds, with a wall of bone between each nostril."

"We feed our young with meat which we bring up from our crops," remarked the King Vulture. "We never carry away our food in our claws; they are too weak, and we always feed in company, several of us together."

"We tear the flesh with our strong beaks," said the Condor.

"I am the King Vulture," cried the other. "When I join a company at a meal, no other Vulture dare begin to eat until I have taken all I want."

"Shall I tell you about my last feast?" asked the Condor.

"No!" I answered. "You have said enough. It is only because you are of some use in the world that you have been allowed to speak at all."

HAWKS

"Once upon a time," sighed the Peregrine Falcon, "we Falcons were the happiest of birds. Nobles and great ladies petted and made much of us: we were the favorites of kings."

"Why?" asked the Kestrel, which is sometimes called the Windhover, because of the pretty way it has of hovering in the air.

"How stupid you are, little bird!" cried the Falcon sharply, opening its beak and showing the two teeth in the upper part.

"I am your cousin, and a bird of prey with curved beak and claws, which help me to kill," answered the Kestrel meekly.

"You kill nothing but mice and insects," said the other with a little shriek of scorn. "I hunt grouse, pheasants, partridges, ducks, and pigeons, and when I am by the sea, puffins and sea-gulls. They are fine sport, I can tell you, and good eating too."

"For killing them the gamekeepers kill you," said the Kestrel spitefully.

"More shame to them," answered the Falcon. "In the olden days no man dared harm one of us. The Falcons were caught when young, and tamed by the Falconers, whose duty it was to train

them for the noble sport of Falconry—which means, little bird, that we were trained to chase the Heron and the Kite and kill them."

"I know all about it," interrupted the Sparrow-hawk. "We Hawks were also trained for the chase. We too wore little hoods over our heads, and sat on the wrists of nobles and great dames when they went a-hunting. And oh! how we longed for the moment when the hood was lifted, and we set free to pounce upon our prey."

"You Hawks are never so skilful as we are in the chase," said the Falcon, proudly, "although you do belong to the same family. You have not our dash and courage."

The Sparrow-hawk was a hen-bird. The hen-birds in both Falcon and Sparrow-hawk are bigger and braver than the cock-birds.

"Perhaps we are not so skilful as you are in the chase," she said, moving one of her long legs angrily, "but we are very fierce and courageous, as the pheasants, whose chicks we rob, would tell you."

"I wish you would leave the chicks alone," complained the Kestrel. "Surely you can find plenty of sparrows and small birds to eat. The Kestrels are often killed by the farmers because of your misdeeds. And yet we do a great deal of good by destroying mice and moles."

The Falcon twitched his broadly barred tail. "You talk too much, little bird," he said. "You never chased the Heron or built your nest on a high precipice."

"I build in towers," said the Kestrel.

"You would never dare to attack an Eagle if it came to disturb your nest," went on the Falcon, proudly, and so saying he flew away.

SEA-GULLS

"Fine day with good sou'wester blowing!" cried the Herring-gull as the Tern flew past the rock. He spoke in a loud harsh voice, for the spring tide was coming up with a rush and a roar, and he was afraid that his cousin might not hear.

But the Tern did hear. "Good fishing!" he said, meaning "Good morning," of course, and alighted beside the Gull. "Oh, I am the swallow of the sea," he said, "and I fly so swiftly and so daintily!"

"Any one can see that you fly well," answered the Gull gruffly; "your wings are long, even longer than mine, although they are not so strong."

"It is a pity your beak is so coarse-looking," remarked the Tern. "That slight bump on the top, and that orange splash of color underneath, quite spoil its beauty."

"Strong sea-wind a-blowing and a-blowing!" cried the Gull, who really did not care what his bill looked like so long as it helped him to catch crabs and fish.

"Where is your mate?" asked Mrs. Gull from the nest.

"Mother Tern is sitting at home in our nest. She has two eggs to hatch," answered the Tern proudly.

"So have I," said Mother Gull. "But how can you call that shallow hole in the sand lined with seaweed a nest? You Terns do keep most untidy nests, and very often you do not trouble to line them at all."

The Tern did not reply, but flew down to the water to skim along it, every now and then ducking down his head to snatch at a fish.

"Those Terns have no manners," said Mother Gull.

"Cousins of ours! Cousins of ours!" bawled her mate.

Up flew the pretty Tern to the rock again. As in all the Gulls, his nostrils are placed far down on the beak, and his webbed feet are made in the same way, except that the fourth toe, the one behind and separate from the rest, is shorter.

"Have you been inland lately?" he asked.

"We only fly inland when the weather is stormy and we cannot find food in the sea," answered the Gull; "there are grubs and insects to be picked up in the fields."

"I prefer the seacoast and the sea with its fish," remarked the Tern.

"So do I, but one must live," answered the Gull, and then he flapped his wings and cried out louder than ever: "Little Gulls coming soon—coming soon—and the wind's a-blowing and a-blowing."

"Good fishing!" shouted the Tern merrily, and flew away home to his mate.

DOMESTIC POULTRY

"Breakfast is ready! Come! Quick, quick, quick!" clucked the old Hen, hurrying along the Chickens as fast as she could, for the Farmer's wife had already put down the pan filled with delicious scraps, and the Cocks and the Hens, the Ducks and the Geese, and the great big Turkey were crowding round about it. "Get into the dish, children," said the old Hen anxiously. She was a very good and loving mother, and she wanted her Chickens to grow up to be fine fat Cocks and Hens.

"Cock-a-doodle-doo!" crowed a Cock, "the sun is rising!"

"Cock-a-doodle-doo! You are wrong; it has risen," answered a second Cock, coolly snatching a piece of bread out of the other's beak.

"Thief," cried the first, shaking his red comb angrily.

"Is this the right way to scratch, Mother?" asked one of the Chickens.

"Quite right, my pet," answered the old Hen. "Our feet are made for scratching, so scratch away, dearie. You will find all kinds of titbits in the earth—grubs and insects as well as grain."

"My feet were made for swimming!" quacked the Duck.

"Then I wish you would keep to the water," snapped a little Bantam Cock. "You have nearly emptied the dish, and my crop is not full yet. Surely you can find plenty to eat in the pond with that flat beak of yours to help you sift the mud?"

"What a noise you little birds do make, to be sure," gobbled the Turkey. "My native place is America, and the wild Turkeys here are very fine birds. They fly very well indeed!"

"So can wild Ducks," remarked the handsome Drake.

"That is an old story," crowed the Bantam rudely, "and we are all tired of it." The red skin on the Turkey's neck grew redder and redder—he was so angry. Up waddled the Geese. Their webbed feet are not so big for their owners' size as those of the Duck, but their beaks are longer.

"What! Quarreling again?" they hissed in a chorus. "Oh fie! For shame!"

"You will all be killed and eaten soon, you little birds!" gobbled the Turkey, who could scarcely speak for rage.

"So will you," shrieked the Bantam, "you conceited old bird. Thanksgiving is coming!" At this the Cocks crowed, the Geese hissed, the Ducks quacked, the old Hen gathered her Chickens under her wing, and the clucking Hen cried ever so many times, "Soon I am going to lay an egg—lay an egg!" Oh, what a noise there was! And when all was quiet—for the Turkey went off in a huff—they all turned again to the dish, and lo! it was found to be empty. For the Hens had never stopped eating all through the quarrel, and they had finished every scrap.

PEACOCK AND PEAHEN

The Peahen was sulky and very cross, and she was quite right to be, for that morning the Peacock in a spiteful mood had pecked her sorely, and she did not think she deserved it. The Peacock, like Bluebeard, had a great many wives. This one was his favorite, so, to make her forget his unkindness, he said: "Come and take a walk, my dear! The sun is shining bravely, and perhaps I will spread out my beautiful train for you to see."

"I am tired of looking at your fine train, if you mean that tail," answered the Peahen crossly. "You think of nothing else."

"How many times must I tell you that my beautiful train is not my tail," cried the Peacock harshly. "I wish you would pay more attention to what I say. My real tail is placed underneath the train, so that it may hold up the long feathers when they are spread. Now do come for a walk! Whatever you may say, you know you like to admire my beauty. I am the most beautiful bird in the world."

"Your voice is very ugly and so are your scaly legs," remarked the Peahen. The places where he had pecked her were hurting still. But the Peacock paid no heed. He had opened his beautiful fan-like train, and was strutting up and down, gently rustling the shining feathers, his little glossy head held up proudly, as much as to say, "Did you ever see anything so beautiful?" The Peahen looked at him and almost forgot his spiteful temper, scaly legs, and harsh voice, and I think she would have forgiven him at once had she not remembered that she had to lay her eggs in secret places because the Peacock often destroyed them.

"I belong to the Pheasant family," cried he. "My nostrils are placed very far down on my beak, and covered with soft skin. I am an Indian bird, and they say that the wild Peacocks in India are more beautiful even than I am."

"You are not beautiful when you are molting," said the Peahen spitefully, "for you lose your long feathers."

"But they grow in again longer than ever after each molt," answered the Peacock. "Now do be friends and come for a walk. We shall, no doubt, pick up some scraps, or a worm or two."

The Peahen, after first giving herself a sand-bath—for the Pheasant family do not wash in water—made up her mind to go. And away they strutted together, the plain little Peahen and the splendid Peacock, and so I heard no more. But I am not sure that I did not see the Peacock begin to peck his wife again very soon afterward. He had a bad temper.

ALLIGATOR

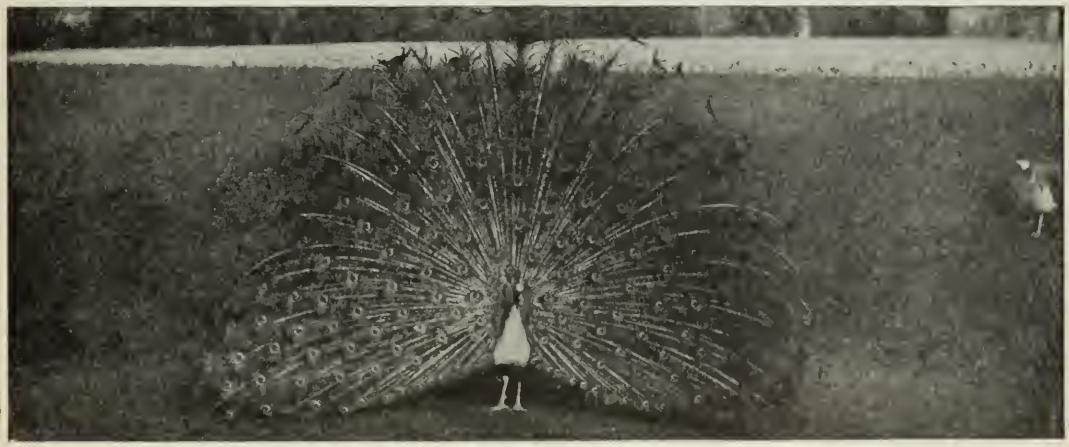
"Come over here, won't you?" said the Alligator to a little boy, a stranger in this country, who had come down to the river to bathe.

"Yes, yes! Would n't you like to catch me, Crocodile?" cried the boy.

SHOWING OFF

ONE!

TWO!!



THREE!!!

"I am not a Crocodile," answered the beast. "My head is shorter and broader than a Crocodile's, my teeth are more uneven, and my horny scales are differently placed; besides, Crocodiles live in Africa and India, Alligators here in America. But come nearer and I will tell you more!"

"Not I," said the wary little boy. "Tell me what you do in the winter, Alligator!"

"Bury myself in the mud and sleep," answered the Alligator, coming a little closer.

"I suppose you are pretty hungry when you wake up again," said the boy. "What do you eat, Alligator?"

"Fish or any creature that I can catch coming down to the river to drink," answered the Alligator, snapping its huge jaws. "I catch hold of the beast, drag it under the water, drown it, and tear it to pieces."

"Oh!" said the boy, moving farther up the bank, "and don't you get water in your eyes and down your throat?"

"Not a drop," answered the Alligator, smiling wickedly. "I can pull down over my eyes little curtains of skin, so thin and clear that I can see through them; and I can close my nostrils and the passage at the back of my throat. Besides being a reptile, I can live both in water and on land. My blood is cold, and my feet are partly webbed." All this time the Alligator was edging closer and closer to the bank.

"Don't you lose a great many teeth tearing flesh?" asked the boy.

"Yes," was the answer, "but other, larger ones grow again in their stead."

The little boy ran up the bank. "Not so fast!" cried the cunning beast. "Wait for me." And very clumsily he lumbered up the bank after the boy, who carefully kept beyond the reptile's reach.

Just then along came another boy, who knew all about Alligators, and hearing the Alligator say, "Wait for me," he whispered to the first boy, then replied:

"If you will put out your tongue we will wait for you." He knew he was quite safe in saying this, for an Alligator cannot put out its tongue. The beast knew it too, and grew angry. "I will eat you!" he snapped, giving chase. The two boys ran, not straight before him, but in circles, keeping well out of reach of the Alligator's tail, often used to knock down its prey. They ran in circles because the second boy knew that Alligators cannot turn quickly.

So the game went on until the Alligator went back in a rage to lie in the water, with nothing showing but the end of his snout, where the nostrils are, and his little wicked eyes. And the two boys ran away laughing.

TORTOISE AND TURTLE

"Tortoises and Turtles are very much like each other," said a little girl, as she passed through the Reptile-house, where all the creeping beasts are kept.

The Tortoise put its funny head out of the house of shell which it carries on its back. "Cousin Turtle," it said, sleepily, wagging its head from side to side, "did you hear?"

"I did," said the Turtle, solemnly (it lived in the next tank). "Fancy a great traveler like me being compared with a stay-at-home like you! *I* come from a beautiful warm place in the tropics, and every year I used to paddle across the sea to Ascension Island with the other Turtles—a thing you could never do, for you have no flippers, and you cannot swim."

"I like paddling in the mud," answered the Tortoise, meekly. "I come from the Galapagos Islands, where all the biggest Tortoises live. We did not travel over the sea, but we often went on long walks, from the shore to the springs, to drink the fresh water."

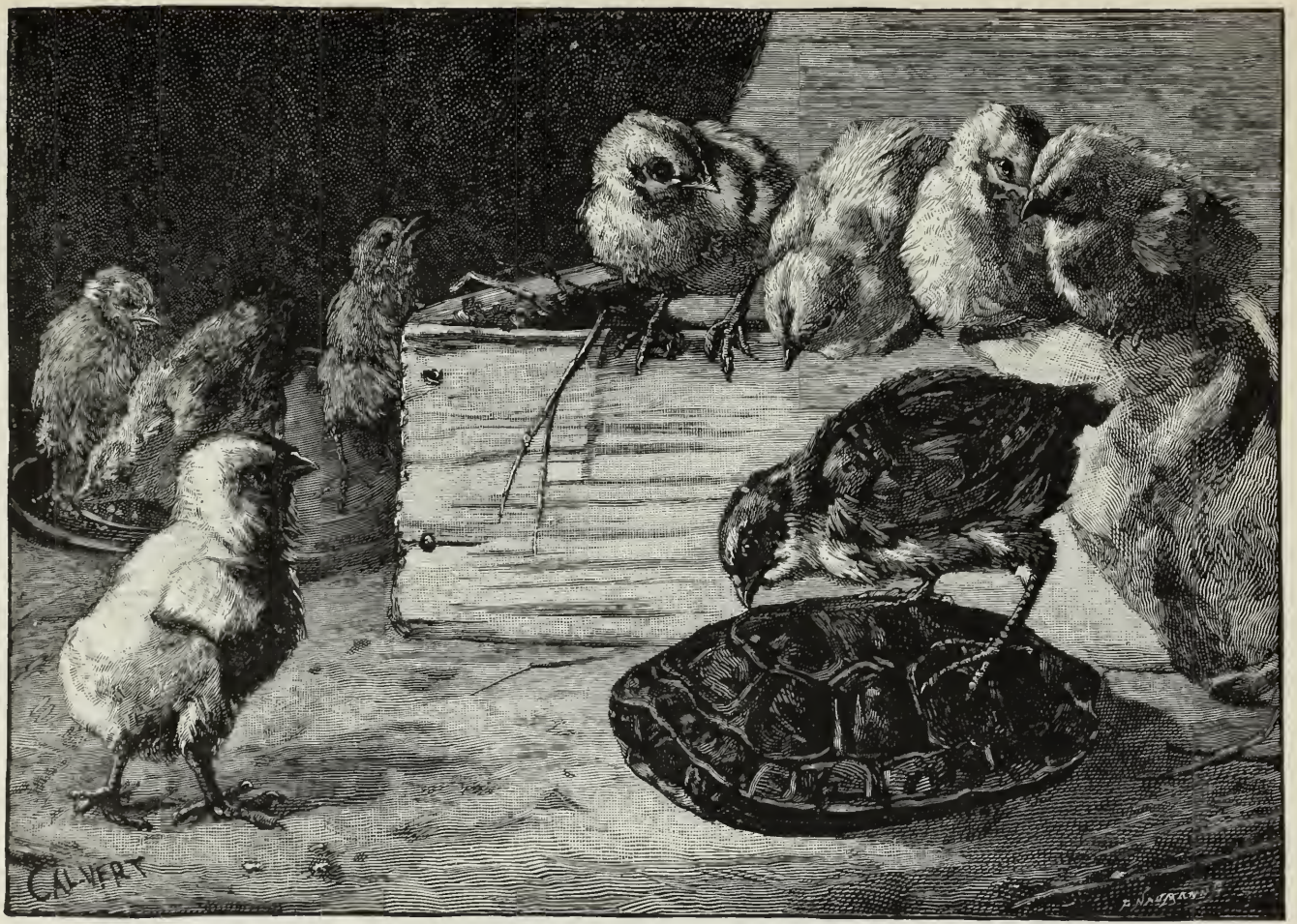
"When our mothers arrived at Ascension Island," the Turtle said, "they began to dig holes in the sand with their flippers. Then they laid their eggs in neat rows inside the holes, covered them over with sand, and left them for the sun to hatch. I was born there. Sad to tell, most of my brothers and sisters were eaten as soon as they came out of the shell by the land-crabs and the birds of prey. I myself managed to reach the sea safely, for we can always find our way to the sea, but even then I was nearly devoured by the hungry fishes."

The Tortoise put out one foot cautiously. "Do you know that there are Land-tortoises, Sea-tortoises, River-tortoises—Tortoises of many kinds?" it asked. "In the Galapagos Islands the Tortoises are so big that it takes eight men to lift one."

"I have not any teeth," said the Turtle, who did not care how big the Tortoises were. "My jaws are covered with horn, so that I can grind the seaweed. The natives use our shells for boats, for children's baths, and for roofing their huts. They catch us while we are sleeping, by turning us over on our backs; we are helpless then."

"We live to be very old, and we are very good to eat," said the Tortoise.

"Green Turtles make beautiful soup," answered the other. "The Hawksbill Turtle has a very fine shell. It costs a great deal of money to buy, and it is called Tortoise-shell. Beautiful combs are made of it."



THE INVESTIGATING COMMITTEE.

"But a Turtle is not a Tortoise!" said the Tortoise.

"We are both reptiles, that is to say, we creep; and our blood is cold." So saying, the Turtle popped its head back into its shell, and they both went to sleep.

SNAKES

"WHO is not afraid of me?" hissed the Snake from behind the tree.

"And who are you?" asked the Boa-constrictor. You must know that the Boa-constrictor lives in South America and the Cobra in India, but somehow or other the two found themselves together.

"I am the Cobra," answered the other.

"Oh, indeed!" said the Boa-constrictor. He was coiled round the tree. "And what is a Cobra?"

"Have you no eyes?" hissed the Cobra, whose temper was not good. "Can't you see that I am a Snake like yourself?"

"Yes, I have eyes, a snake's eyes, with a curtain of transparent skin instead of eyelids. I can see that you are a Snake and a Reptile, and that you creep. I suppose that your bones are all jointed like mine, and that your scales are made of thick skin, and that both jointed bones and scales help you to get over the ground; and I suppose that you have two scaly skins, an outer one and an inner one, and that when molting-time comes you cast off that outer skin, or scarf as it is called."

"You may suppose what you like," answered the Cobra crossly.

"Then I suppose," said the Boa, "that when you are hungry you coil round a tree, and when a small animal passes, you catch hold of it with your teeth, twist your body round it, and squeeze it to death as I do."

"You suppose wrong," hissed the Cobra. "I kill with my poisoned fangs. Who is not afraid of my deadly bite?"

"By the hundreds of bones in my body, head, and tail, I am afraid of nothing," cried the Boa. "Even men dare not attack me unless I have overeaten; then I grow sleepy and stupid and am easily slain." Then looking more closely at his neighbor, the Boa added, "Do you always have a swelled neck, Cobra?"

"Take care, sir, your teeth are not poisoned!" answered the Cobra, and his neck or hood grew bigger and bigger. A Cobra's hood always swells when he is angry and about to strike.

"I suppose," said the Boa, "that when your prey is dead you swallow it whole, beginning at the head, but first covering the animal or bird with slime from your mouth so that it may slip down more easily. And I suppose that your jaws are elastic and can stretch ever so wide apart."

"Glutton," hissed the Cobra, "I do this, but I eat smaller animals than you—birds' eggs, mice, frogs, and even insects."

"I suppose—" said the Boa, but he stopped suddenly: the Cobra looked so very wicked!

FROG AND TOAD

"GOOD morning!" croaked the young Frog in the stream, to the old Toad on the bank. "Won't you come and join me?" He was a bullfrog, and had a very deep, loud voice.

"Not this morning, thank you," answered the Toad politely. "I have not so many air-bladders as you have, so I am not as happy in the water. Besides, it is raining."

The Frog swam to land. "If you like," he said, hopping up to the Toad, "you shall hear the story of my life. A great many things had to happen, I can tell you, before I came to be the fine young Frog that you now see."

"I know," said the Toad; "I have been through it all too."

"I was the six hundredth egg that my mother laid," croaked the Frog proudly. "All last winter she buried herself in the mud and slept, but in the spring she began to lay her eggs. I was the six hundredth."

"So you said before," said the Toad hoarsely. "I saw the Frog's eggs floating on the water, little black spots covered up in jelly, and spread out most untidily. Now my mother lays her eggs in a neat line of float-jelly."

"Those little black spots soon leave the jelly, for they grow into Tadpoles," said the Frog. "Yes, Mr. Toad, I was once a nice little Tadpole with a tail just like a fish."

"So was I," answered the Toad. "And like you I breathed through little fringes at the side of my head. Gills they are called."

"First," said the other, "my hind legs began to sprout, and then my front legs. My teeth came, and I had to rise to the surface to breathe the air, for I was beginning to have lungs."

"My front legs came first," remarked the Toad. "And I have no teeth."

"And then my tail dropped away, and I became a clever, little, cold-blooded Frog, that can hop on the ground and swim in the water," boasted the Frog.

"I cannot hop," said the Toad, "only crawl."

"Poor thing, and you are so ugly too," croaked the Frog, "so much broader and flatter in shape

A CAT TAIL

"Oh, see, grandpa. Oh, just look there!
Meow! meow! What can it be?"
Said grandpapa: "I do declare,
That 's our ancestral tree!"

than I am, so much darker in color. And what a very wide mouth you have!"

"My eyes are large and beautiful," answered the Toad angrily. "I, too, am amphibious, which means that I can live either on land or in water. Be careful what you say, you wretched little hopper!"

The Frog jumped with fright. The Toad has a secret store of bitter fluid in its head and shoulders, and Mr. Froggie was afraid of being sprinkled with it. "Don't let us quarrel," he croaked, "on such a nice wet day. Let us go into that garden and eat slugs and insects."

SHARK AND PILOT-FISH

The Blue Shark had been enjoying himself. He had bitten the Cornish fishermen's nets into pieces, and stolen all the fish that were in them. He had eaten four Mackerel, a Conger-eel, and ever so many Herring, and he felt very comfortable indeed after his meal. The Pilot-fish was with him; indeed, I am not sure that it was not the little Pilot-fish who had shown the Shark where the nets were; at any rate, he was there and enjoying the fun too. He was not afraid of the Shark, for the two are great friends, and often travel together.

"Come to the bottom of the sea!" said the Shark, taking a mouthful of water, and letting it run out through his gills. He was breathing when he did this, for there is air in the water. Fishes have no lungs; instead they have gills placed at each side of their heads. When the two reached the bottom they met a Diver. "Hallo!" cried the Shark. "What a queer fish!" and he opened his mouth and showed all his teeth. The Shark has triangular or three-cornered teeth, with edges that cut just like a saw.

"That is a man," said the Pilot-fish.

"I might knock him down with my tail," said the Shark pleasantly, "or I might bite him in two."

"What are you doing here?" asked the frightened man.

"I come to the English coasts for my summer holidays," answered the Shark. "For the rest of the year I stay in warmer seas."

"Are you the Blue Shark?" asked the Diver.

"Of course I am," answered the Shark. "Look at my blue fins and tail! The big fins and tail I use for swimming, and the little fins help to keep me steady in the water. I suppose you are frightened at all the Sharks. We are a fierce tribe."

"Like that of all fishes, your blood is cold, I believe," said the man. His friend was beginning to pull him up, and he was less afraid. "The fishermen catch you and use your body for manure and make oil out of your liver. Out of the skin of another kind of Shark shagreen, a good kind of leather, is made."

LOBSTER AND CRAB

"Is it peace or war?" asked the Lobster of the Crab, one day, as they met at the bottom of the sea. "Peace," answered the Crab.

"Shake a claw, then," said the Lobster.

"Which claw?" asked the Crab. "I have ten. I am the great Crab, which the land-creatures like best to eat."

"I 'll shake the big nipper, please," said the Lobster, so they shook claws and settled down to talk.

"We are knights of the sea," said the Crab, "covered with armor, head and claws and body and all."

"We are knights belonging to the Order of the Crustacea," cried the Lobster, proudly waving one of his long feelers.

"Oh, what a big word! What does it mean?"

"Crustacea means creatures covered with a crust or shell."

The Crab's little eyes, which are set on eye-stalks, twinkled. "You do know a lot," he said.

"I learned it in the lobster-pot that time when I was nearly caught by the fisherman."

"That time when you lost a claw?"

"Yes," answered the Lobster. "When the man took me out of the pot I nipped his hand. He tried to shake me off, and then I jumped into the sea again, but I left my claw nipping his thumb. However, another soon grew in its place."

"I can throw off my claws, too, when I like," said the Crab, "and when molting-time comes I slip right out of my shell, and leave it lying on the sand, because, you see, I have a new shell growing underneath. This is soft at first, but it soon gets hard, and I find myself bigger and stronger than before."

"It is the same with me," said the Lobster, waving the tail that helps him to swim. "Our claws and bodies are made of rings of shell joined together. We use some of our claws for walking, and some for tearing up our food."

"We have teeth in our stomachs for chewing," cried the Crab.

"Land-creatures like to eat us," said the Lobster, "especially me. When I am cooked I turn to a bright red color, but in the water I am green."

"Well! if you wish to keep green don't walk into any more lobster-pots," said the Crab.

STRANGE FISH AND REPTILES

FISH SUFFERING FOR LACK OF AIR

A WRITER tells us that he once observed a singular incident on a marsh near Lake Ontario. Some French Canadians had cut a hole through the ice, which was quite a foot thick, and bullheads were swarming to the surface of the water in such quantities that they were being shoveled out on the ice. As soon as the men had secured all that they could carry they hurried away. But still the fish swarmed to the surface, struggling with one another to get to the air.

A man who had made a study of fish, told the writer that the fish were suffering for want of pure air to breathe. Regarding this observation, another student of the habits of fish says that this same freezing over must occur every winter, but it is only in severe winters that the fish are really suffocated. This lack of air under the ice is to some extent compensated for by the hibernation of some fishes, but in shallow water the ice is likely to form on the bottom ("anchor-ice"), and the fish are then readily killed.

We are also told that a fish, though living in the water, requires the same kind of air that we do. By means of their gills fish breathe the air dissolved in water. The oxygen consumed by them is not that which forms the chemical constituent of the water, but that contained in the air which is dissolved in the water. Fishes transferred to water from which the air has been driven out by a high temperature, or in which the air absorbed by them is not replaced, are soon suffocated. They require aërated water to maintain life, and they take it in constantly through their mouths and expel it through their gills, retaining the air. It follows that if the water in a lake should be completely cut off from contact with the air long enough to exhaust the supply of air, the fish in the lake would die. It would take a severe and pretty long-continued freeze to accomplish this, but it might happen, and doubtless has frequently happened, with a small body of water.

THE PORCUPINE FISH

THE picture which you see below is that of a *"Cirrhosomus turgidus,"* and it surely looks like it. In its normal condition it is not unlike a common black bass of fresh water. The body is inclosed in a sac capable of great distension and is not attached to it except at the head and tail. This skin or sac is covered with spines varying in length, hard and smooth as ivory and sharp as needles. When it is caught or when any danger threatens it, it immediately inflates itself to several times its usual size, by short inspirations, the inflation being by absorption of water if the fish is submerged, and by air if it is at the surface. Scratching it underneath, or rapping it lightly will cause it to discharge its load through the mouth and gills, and then inflate again; and this operation may be repeated several times in succession.

This envelope when not inflated does not shrink close to the real fish body, but wraps itself by

THE PORCUPINE FISH.

even folds, like accordion pleats, around the circumference, the spines lying flat along the body. At the head where the thin skin is fairly attached, the spines are shorter, thicker and remain standing upright in one position.

This fish has no teeth, but the jaws, upper and lower, are notched, like a saw; there are no scales. When the body is removed and the skin dried it becomes as hard and tough as parchment.

If it be true that big fish feast upon small ones, this one must be a tough article of breakfast food. When a voracious shark comes in sight, the porcupine fish swells himself to full size, wags his tail in a friendly way and chuckles in glee at the prospect of fooling the "hold-up" chap. The shark, seeing the fat, juicy morsel, prepares for a dainty fish dinner, takes him in at one gulp, and gets nothing but a mouthful of sharp pins and a dose of salt water.

What is the porcupine fish good for? Not for eating, surely. To man it is simply a curiosity. When the fish is killed and the skin dried in its distended condition, it can be turned into a fancy lantern by making an opening at the top and inserting a small electric globe, which when turned on shines with a mild light through the eyes and mouth and almost transparent skin, bringing out the fish shape very nicely.

Porcupine fish are usually caught by the net, but occasionally the fisherman may be lucky enough to induce one to take a hook.

W. J. HANDY.

A PORTUGUESE MAN-OF-WAR

DEAR MR. EDITOR: We went out rowing and saw a "Portuguese man-of-war," a tremendous jellyfish. It looked like a huge bubble, and its color reminded us

PORTUGUESE MAN-OF-WAR.

A remarkably good illustration from a photograph by Ward's Natural Science Establishment, Rochester, N. Y.

of the rainbow. A fringe adorned the body, and altogether it was a curious thing, and in the distance might easily be mistaken for an electric light shade. Its feelers, or tentacles, are long and poisonous, and if you should happen to meet the creature unawares while you were swimming in the sea, it would wind them around your arm and painfully sting you.

Your loving reader,
A Thirteen-Year-Old Girl.

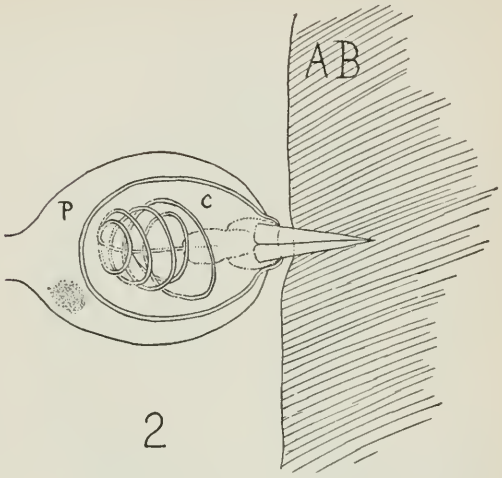
In the region of Woods Hole, Massachusetts, this interesting and beautiful sea-animal appears, in varying numbers, about the first of July of every year. At times they are so numerous that they occur by the hundred, while at other seasons only a few are seen at long intervals.

The fringe to which our correspondent refers is formed of what the scientific man calls "long, locomotive tentacles, which, when the animal is driven by its broad sail, or float, before the wind, stretch out in large individuals from thirty to fifty feet," and are indeed formidable things, not only to the person whose bare flesh comes in contact with them, but to various smaller and weaker creatures some of which they have the power to sting to death.

In reference to this man-of-war, Professor A. S. Packard says: "It is excessively poisonous to the touch, and in gathering specimens on the shores of the Florida reefs, we have unwittingly been stung by nearly dead individuals, whose sting burns like condensed fire and leaves a severe and lasting smart." Yet there is at least one little fish that fears no harm, for it is often seen in company with the man-of-war, and when frightened runs up among the tentacles to hide. Some human beings are so affected by the stings and the poison, that they suffer for a long time, and are actually made ill by them.

In the large figure, the Portuguese man-of-war is shown, and in the smaller ones the minute stings in various stages of what may be called their "explosion," for the force with which they dart out of the tentacles is so great that "explosion" describes it well, although they are so minute that they can be seen only with the microscope. The figures are therefore highly magnified.

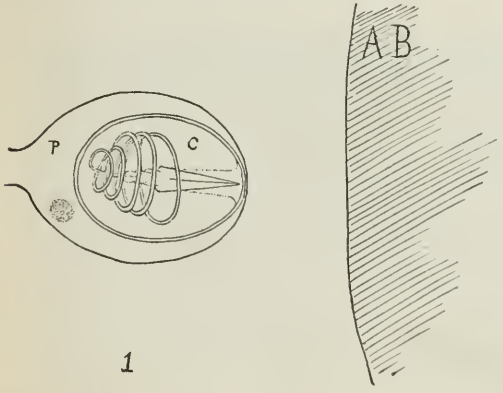
As with the sting of a bee, it is not so much the weapon itself that gives the pain, as it is the poisonous liquid that accompanies it. In the man-of-war, these stinging cells, which occur by the myriad in the tentacles, are expelled on coming in contact with the surface of the enemy, and that enemy pretty soon knows that something has happened to him.



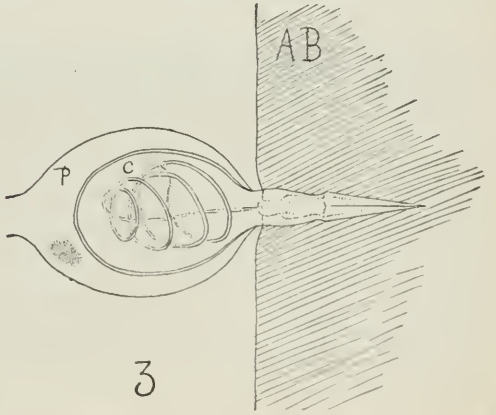
THE ARROW-HEAD OF STING ENTERING VICTIM.

In Fig. 1, AB represents the victim to be stung; C is the cell that contains the poisonous liquid, and the sting itself, which has a head that appears to be shaped somewhat like that of an arrow, but is really more like a long pyramid. Connected with this is, as shown, a coiled, hollow tube through which the poison is said to be forced. The whole cell seems to be under great pressure and is always ready to explode at a touch, and to hurl the dart into the victim.

In Fig. 2, the touch has been made and the explosion has taken place. The arrow-head, which



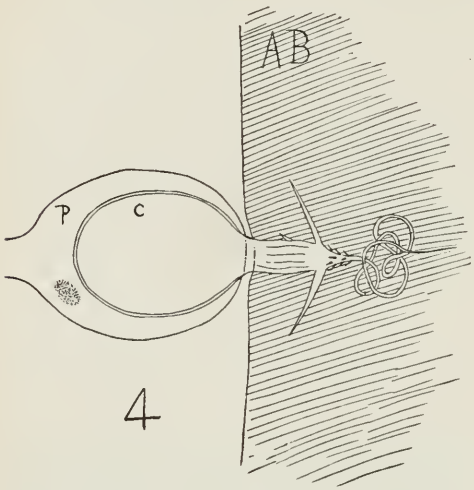
AB REPRESENTS VICTIM TO BE STUNG. C, STINGING CELL, WITH P, POISONOUS LIQUID.



THE NEXT STAGE OF THE STING ENTERING THE VICTIM.

is really a pyramid, is entering the flesh, and the coiled thread is beginning to straighten out.

In Fig. 3, the head is extended to its full length, and the thread is still straighter, while the poisonous fluid is probably rushing through its hollows and giving the victim something to think about.



THE BARBS OF STING FASTENED IN VICTIM.

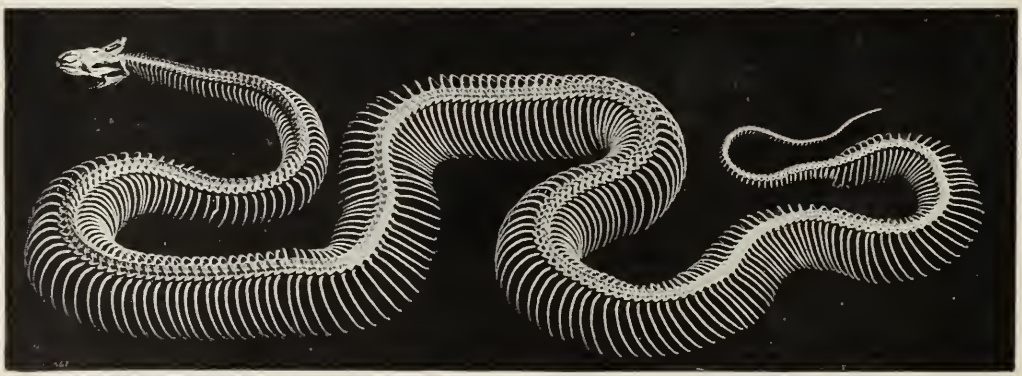
Now what I have called the head of the sting is composed of three stiff barbs that are folded together to form a pyramid, as shown in Figs. 1, 2, 3; but when these parts get into the skin or the flesh, a remarkable thing takes place. They speedily separate, they instantly swing about and turn down, and form an anchor with three of the sharpest kind of flukes, and as they flash backward, they tear a space into which the hollow tube is thrown. This is shown in the diagram, Fig. 4. In addition to this terrible anchor, the figure also shows that there are several sharp, little strengthening barbs, just behind the hollow tube through which the poisonous liquid is said to pass.

When you remember that there are thousands of these darts entering the victim all at once, you will perhaps feel less surprise at the man-of-war's power to sting every soft body, and to kill smaller and weaker creatures. But it adds much to the interest, I think, when we recollect that these stings are invisible to the naked eye, and can be seen only with a high power of the microscope.

MANNERS AND MYSTERIES OF SNAKES

Have you ever thought what hidden beauties there are in the beings most shunned by man? Professor Huxley says: "The vertebra of a snake is the most beautiful piece of anatomy I ever saw." The movement of a snake, in the water or on land, is very wonderful and a mysterious sight to the unfortunate man whose limited acquaintance with nature has not enabled him to solve the riddle. "Here," he says, "is a creature with neither legs, nor wings, nor fins, and yet it moves with even more swiftness and grace than most animals which possess these means of getting about. How is it that this can be?"

We will look for a moment at the skeleton. We see that it consists merely of the skull, the backbone, and the ribs. The vertebræ are joined by exquisite ball-and-socket joints, and two ribs are attached to each vertebra, one on each side. Probably you have noticed that the under side of a snake's body is covered with crosswise plates, which scientific men call scuta. Now, instead of having the ribs attached to a breastbone, like the mammals and lizards, the snake has them attached to the scuta, so that, as Miss Hopley says in her valuable book on ophidians, the snake, in-



SKELETON OF AN INDIAN PYTHON. (PHOTOGRAPHED BY PERMISSION FROM THE ORIGINAL IN THE NATIONAL MUSEUM, WASHINGTON, D. C.)

stead of having no legs, really has two for each foot.

A SNAKE'S RIB.

The common blacksnake, *Bascanion constrictor,* whose species name, *constrictor,* comes from its mode of killing its prey, constricting or binding them—in other words, hugging them to death—is our largest snake, often reaching a length of six feet and over. The blacksnake often lives in stone walls, and is fond of climbing into a tree overhanging the water. Here it wraps a few folds about the branches, and watches its chance to snap up any nice little frog which hops by, a bird, if one alights near enough, or perhaps a field-mouse scampering along. This snake has a great deal of curiosity, and is said to follow men and beasts long distances; but it retreats instantly if turned upon. It is harmless, and should you by chance disturb or tread upon it, the worst it would do would probably be to wrap a few folds about your legs, or stick out its tongue, or possibly give you a slight bite.

One of the handsomest of our snakes is the checkered adder, chicken-snake, or thunder-and-lightning snake, as it is variously styled. The title of chicken-snake comes from its alleged fondness for sucking eggs. The accusation may or may not be true; but I found one in a half torpid condition, one early spring day, in a hen-house.

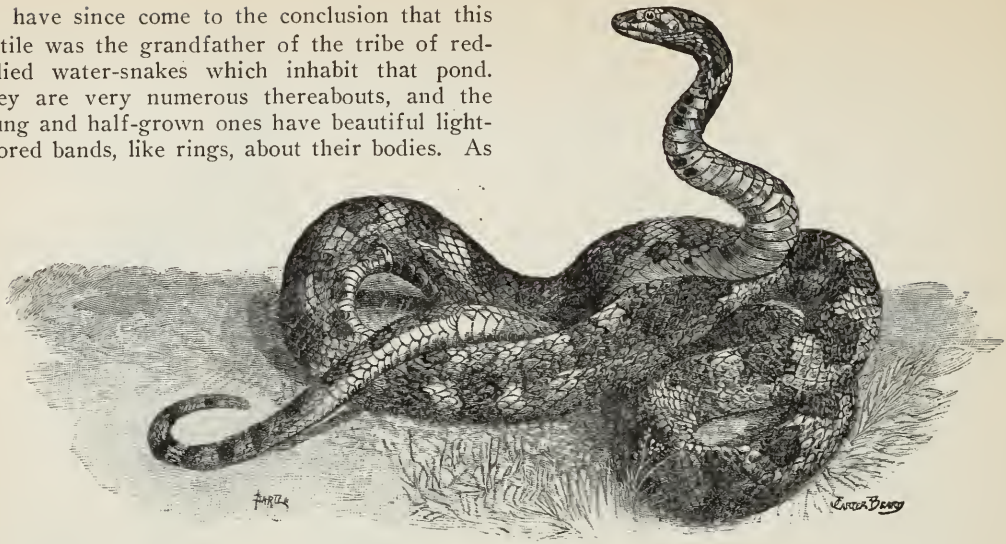
Most of you must have seen the striped garter-snakes of which two species are very common in some parts of our country, the smaller being called the swift garter-snake. The larger one is at home alike on land and water. I have often seen them catching grasshoppers; and here I must stop a moment to tell you of the strange way this snake has of eating. When he catches a grasshopper or a little frog, he opens his jaws so wide that they are actually out of joint. Having taken his food into his mouth, he readjusts the jaws, holds the insect or the animal for some time, so that it may become thoroughly moistened, and then, with a mighty gulp, swallows it. The handsomest snake in my collection is a garter-snake brought to me, by a friend, from Canada, where they grow larger and finer than in New England.

Next in size to the racer, or black-snake, comes the red-bellied water-snake. He is a rough-looking fellow, owing to each of his scales having a little keel or ridge in the middle.

THE BLACKSNAKE.

One warm still day in April I was walking along the shores of a small pond, hoping I should see some signs of the snakes waking from their long winter's nap. Suddenly I stopped. Could those enormous gray-black coils about the roots of that little oak-tree be the body of a snake? I touched them with the handle of my long net; instantly the creature thrust forth a wicked-looking head. How wicked were those fixed, glittering eyes! I stood spellbound, experiencing at once the overpowering fear, mistaken for fascination, which snakes are said to cause in other creatures. Here was a snake, with neither fangs nor poison-sacs, which did not constrict, and yet I felt that he had the power to kill me instantly.

I have since come to the conclusion that this reptile was the grandfather of the tribe of red-bellied water-snakes which inhabit that pond. They are very numerous thereabouts, and the young and half-grown ones have beautiful light-colored bands, like rings, about their bodies. As

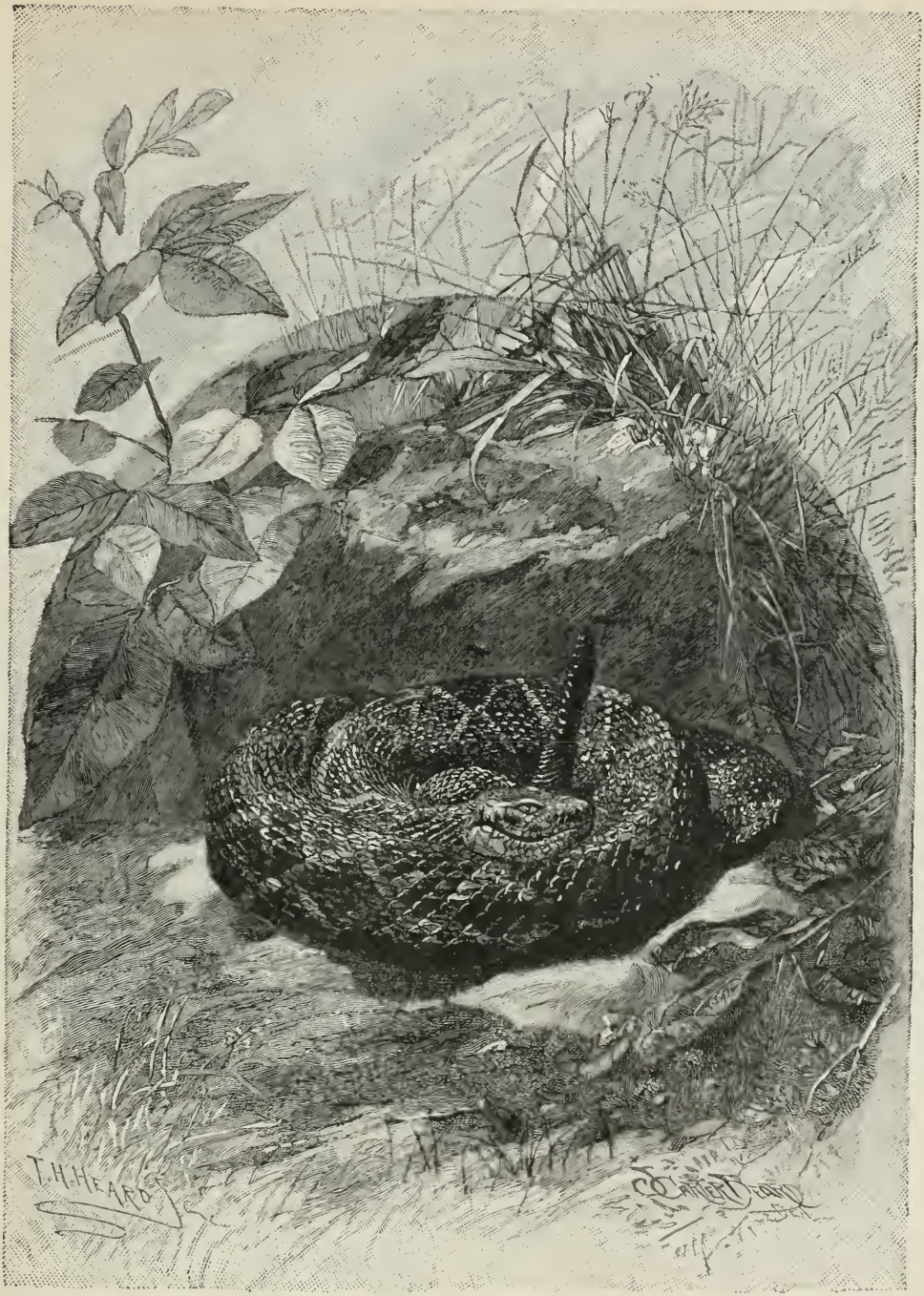


THE THUNDER-AND-LIGHTNING SNAKE.

they swim along, with their heads just above the surface, these bars look like sunbeams striking across the back. I never had succeeded in capturing any but small specimens of this snake, and, as I wanted a good one, with the bright-red color on the under side of the body, which is not attained until he has grown quite large, I started out with my can, net, and thick gauntlet glove, determined to secure a large one if I could.

In the middle of the pond were the remnants of an old raft. I counted five snakes and two turtles sunning themselves thereon. "I 'll have one of those before I go home!" I said to myself. I threw some stones, hitting the raft and scattering its occupants into the water. I waited a long time after this, watching a snake snap up little frogs, and all at once it occurred to me that possibly I myself might make use of a frog for bait. I saw a dead one floating near the bank. Only a few feet out was a large flat rock. I managed to reach this dry-shod, and, stooping, dropped my frog gently into the water. My heart thrilled as I saw a little dark head coming toward the bait. I lay flat on the rock and held my

THE RED-BELLIED WATER-SNAKE.



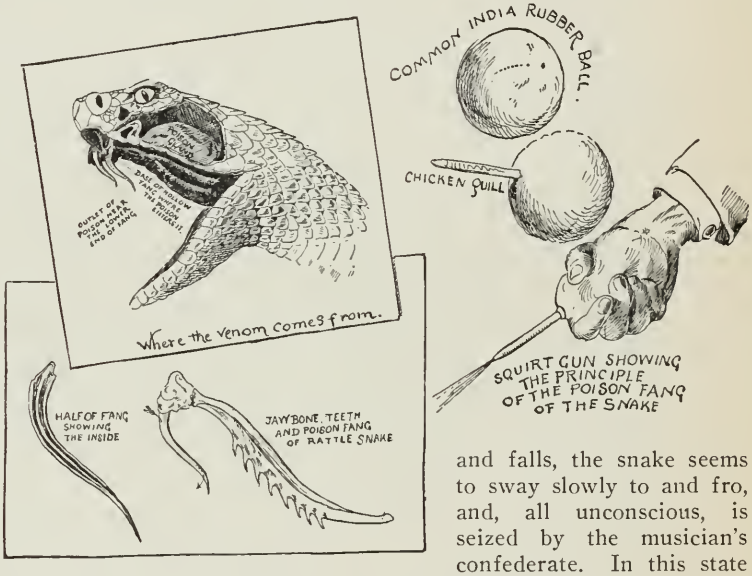
A RATTLESNAKE COILED.

gloved hand ready. Nearer he came and nearer, and when he seemed to be within reach I made a quick plunge to my elbow—only some weeds were clutched tight between my fingers. Another hour of long, patient waiting, and the coveted prize came once more to the surface. This time

I brought him up in triumph, twisting and writhing.

My only rattlesnake was caught alive by a young girl who had that summer killed eleven on her farm in California. This snake has five rattles, which, if we believe they denote the age, will show that he is five years old. Darwin believed that the rattle, besides being used as a warning to keep off the snakes' enemies, sometimes is employed to call their mates.

The heads of most of the venomous snakes, including the "rattlers," bulge just beyond the neck. Without exception they have fangs, either always erect, or raised and laid back at will. These fangs are long, sharp-pointed teeth, with a hollow groove running their entire length. At the root of each fang is a little bag of poison. When the snake bites, the motion presses the poison-sac, and its contents flow down through the hollow in the tooth into the puncture or wound. The harmless little forked tongue is often spoken of by the uninformed as the snake's "stinger." Now, there is no propriety in the name, as the poisonous snakes do not sting, but *bite,* their victims. There is no creature, even if brought from foreign countries where "rattlers" do not exist, but will halt and tremble at the first warning sound of the rattle.



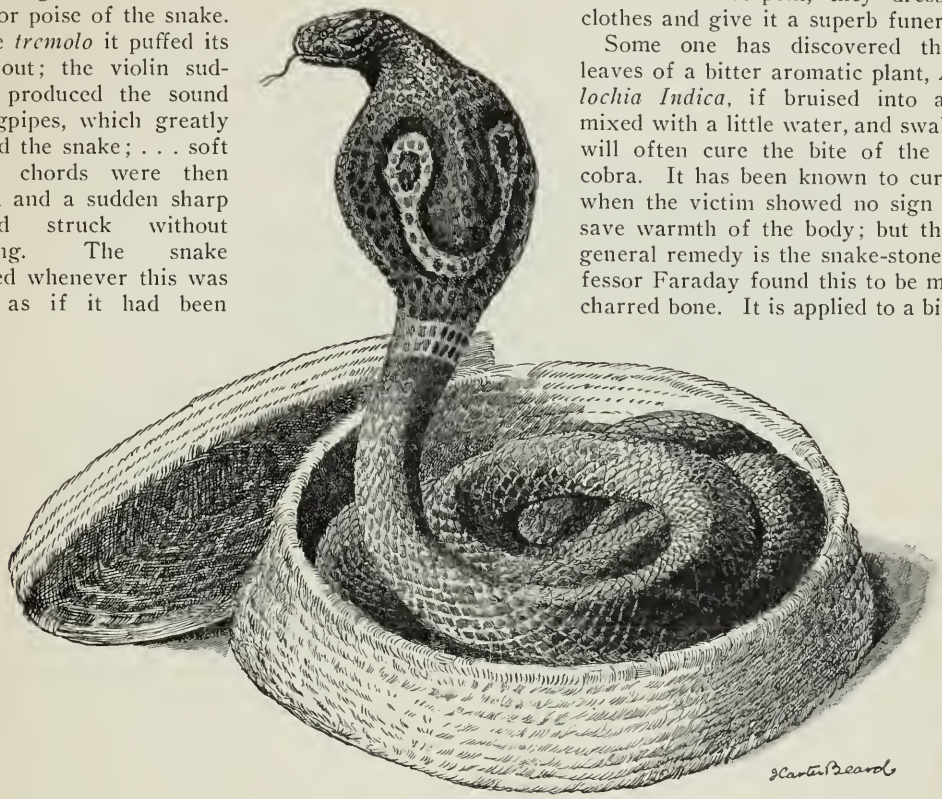
Scientific students who have made experiments with the venom of different serpents have found that, aside from its poisonous qualities, it contains living germs, which have the power of increasing enormously fast. So, you see, when an animal is bitten, these tiny bits of life, entering with the poison, cause harmful action to begin almost at once. Dr. S. Weir Mitchell found that the nervous center controlling the act of striking seems to be in the spinal cord, for if he cut off a snake's head, and then pinched its tail, the stump of its neck turned back, and would have struck his hand had he been bold enough to hold it still.

When a snake has bitten several times, the poison is quite exhausted for the time being, rendering the animal comparatively harmless. It is said to be this fact which enables the East-Indian snake-charmers to handle their charges without danger. They tease them into anger, when they will readily bite a stick or bundle of rags, and so exhaust their venom.

Perhaps it will be well here to say a few words more in regard to snake-charmers. Many kinds of serpents, especially the hooded cobra of India, are thought to be affected by music. In capturing them for exhibition, the native takes his bagpipe, and, stationing himself near an old well or ruin, begins to play. A cobra is almost certain to make its appearance soon, for they are very numerous in that country. They are held in sacred reverence, the little children calling them "Uncle," and setting saucers of milk for them to drink; and they are looked upon as guardian angels. Should one be killed the slayer would suffer death in punishment. As the music of the bagpipe rises and falls, the snake seems to sway slowly to and fro, and, all unconscious, is seized by the musician's confederate. In this state of musical excitement the snakes are said to be quite safe to handle, although I think I should not care to try it myself.

A man who was making investigations on this subject at the London Zoölogical Gardens, hired a violinist, and together they went to the serpents' quarters. In telling what he observed, the investigator said: "We selected for our serenade a large yellow Indian cobra, which was lying coiled up asleep on the gravel at the bottom of his cage. At the first note of the violin the snake instantly raised its head, and fixed its bright yellow eye with a set gaze on the little door at the back of the cage, whence the sound came. The music then became gradually louder, and the snake raised itself in traditional attitude, on its tail, and spread its hood, slowly oscillating from one side to the other, as the violin played in

waltz-time. There was a most strangely interested look in the cobra's eye and attitude at this time, and the slightest change in the volume or character of the music was met by an instantaneous change in the movement or poise of the snake. At the *tremolo* it puffed its body out; the violin suddenly produced the sound of bagpipes, which greatly excited the snake; . . . soft minor chords were then played and a sudden sharp discord struck without warning. The snake flinched whenever this was done, as if it had been struck." This seems to show that the snakes have a highly sensitive nervous organization. The East-Indians say that this snake used to have seven heads, though now it has only one, and that its hood is the remnant of the other six.



THE HOODED COBRA.

The cobra of Africa is regarded somewhat differently by the natives of that continent, some of whom, once a year, kill a cobra-de-capello and hang its skin to the branch of a tree, tail downward. Then children born during the past year are brought out and made to touch the skin. This, their parents think, puts them under the serpent's protection. The cobra-de-capello divides with the horned viper of Africa the questionable honor of being the "worm of Nile," to whose venomous tooth Cleopatra's death was due.

The Kafirs use the venom of this snake's cousin, the puff-adder, to poison their arrows; and when they have any small quantity left they swallow it, having a theory that it will protect them from the bad effects of future bites.

The Snake Tribe of the Punjab say that the bites of snakes do not hurt them; and if they find a dead serpent, they dress it in clothes and give it a superb funeral.

Some one has discovered that the leaves of a bitter aromatic plant, *Aristolochia Indica*, if bruised into a pulp, mixed with a little water, and swallowed, will often cure the bite of the Indian cobra. It has been known to cure even when the victim showed no sign of life save warmth of the body; but the most general remedy is the snake-stone. Professor Faraday found this to be made of charred bone. It is applied to a bite, and when it drops off of its own accord, the patient is said to be out of danger. These stones are used also in Mexico.

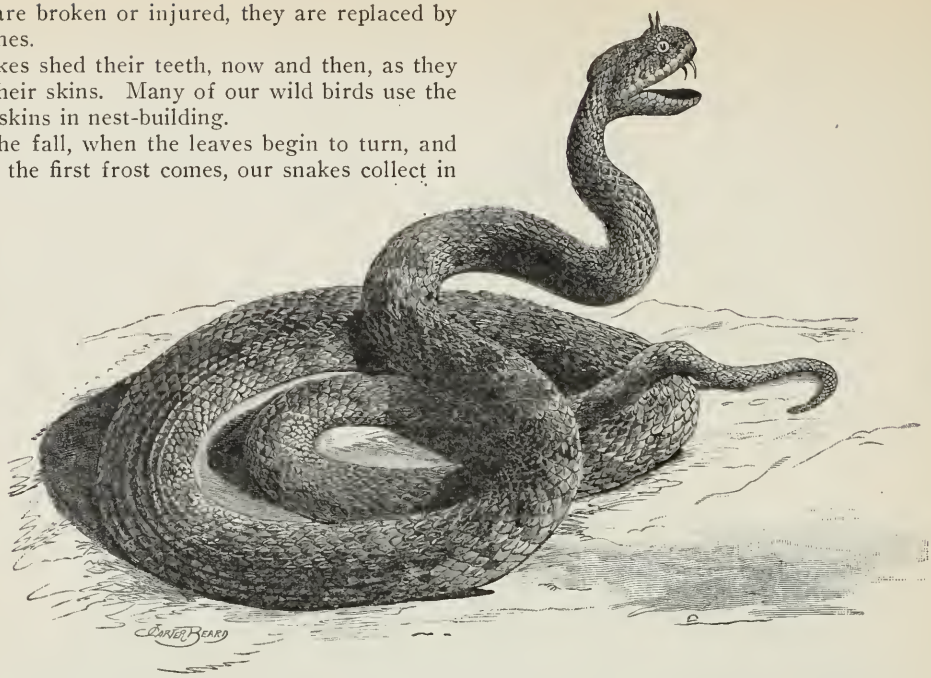
Our own North American Indians will not kill a snake in their path. They hold it in reverence, and although they select great numbers of them to use in their snake-dances, they never kill them, but, when the ceremony is finished, take them out on the plains and release them. Some Zuñi Indians from New Mexico, with whom I became acquainted, refused to repeat their folk-lore out of doors for fear the rattlesnakes would hear.

All snakes, poisonous or otherwise, with the exception of the *Anodon* family, have two rows of teeth on the roof of the mouth, fine, sharp, and pointing backward; so you see it would be very hard for a small animal, once caught, to escape after these teeth have fastened on him. If any

teeth are broken or injured, they are replaced by new ones.

Snakes shed their teeth, now and then, as they shed their skins. Many of our wild birds use the snake-skins in nest-building.

In the fall, when the leaves begin to turn, and before the first frost comes, our snakes collect in



THE HORNED VIPER.

numbers, from three or four to a dozen or more, roll themselves in balls, in a hole in the ground or in a hollow tree, and there they remain in a state of hibernation, or sleep, through the winter. They can live for a long time without food.

One day, as I was putting a snake I had caught into a can that I carried for the purpose, a lady, hunting for botanical specimens, stopped and regarded me some moments in silence. Then she asked me what I was going to do with it. I answered, "Preserve it." Upon which she asked, "Do they make good preserves?"

MARGARET W. LEIGHTON.

CRABS AND THEIR HABITS

WHEN the Roman soldiers first invaded Britain they found quantities of ten-legged creatures scrambling about on the shores. These had eyes borne each on a little stalk, and hard coverings for their bodies as good as suits of armor. The Romans were not slow to find out that these same animals made excellent meals. They called them *carabus*. Thus originated our word "crab." Those crabs which were relished by the invaders are table delicacies in many English homes today.

The baby crabs differ greatly in general appearance from their parents, so that if you should see one floating about in the water you would not connect it with the crabs in any way. After leaving the egg it passes through many stages of development. Less than a hundred years ago, naturalists thought that they had found some very strange new animals when they discovered the young crabs in the various stages of growth. One they called a nauplius, and another a zoëa. We use these same names now to denote the stages of development through which the little crab passes. Mr. Frank Buckland says, in describing one which has just left the egg: "A goggle eye, a hawk's beak, a scorpion's tail, a rhinoceros's horn, adorn a body fringed with legs, yet scarcely bigger than a grain of sand."

In the nauplius stage there are three pairs of legs, and one eye in the middle of the head. Next comes the zoëa stage, and now our little friend rejoices in a pair of eyes, and a number of long, sharp spines which grow out on all sides of its body. As it is still very helpless and not able to fight its own battles, nature has provided the spines as a protection against wandering fishes who might think the little crab a dainty morsel were it unarmed; but when they see the threatening spines they pass it by unnoticed. Next comes the megalopa stage, in which the legs are well developed. Other stages follow, until at last it comes out a perfect copy of its parents.

Once all crabs lived in the sea and breathed by means of gills. After a time there were some kinds which thought, after experimenting, that a life on land would be better than remaining always in the water. In this way, as Carl Semper has discovered, the gill-chambers, consisting of a lower and upper portion, have been transformed, so that now the lower portion only contains the true gills, while the upper portion is an air-breathing lung. The crabs are thus fitted for spending as much time or as little as they choose in their native element and the remainder upon land.

Does it not seem wonderful that some crabs should live on mountains four thousand feet high? They have, in addition to the lung, a little reservoir of water within their bodies for moistening the breathing apparatus when it becomes dry. Though dwelling so far from the sea, they have a strong affection for their old home, and once a year they make a pilgrimage to it to bathe and deposit their eggs. They go in May (the rainy season on the islands in the Pacific and Indian oceans, where they live), in vast hordes, straight to the sea.

Rev. Thomas Stebbing says in his "History of Crustacea": "The army is often a mile and a half long and forty or fifty paces broad. Each soldier marches sideways. They go over everything that comes in their way, be it hedges, houses, churches, hills, or cliffs. They would rather clamber up at the peril of their lives than make a circuit. They sometimes pass in at the windows on one side of a house, right over the occupants, who may be asleep in bed, and out at those on the other side, causing the people no little fright. The vanguard, composed wholly of males, starts some days before the main army. The noise which they make is like the rattling of armor. If any luckless soldier falls and breaks his limbs he is immediately gobbled up by his companions."

THE SPINOUS SPIDER-CRAB.

Unlike most sea-crabs, the young of the land-crabs do not pass through a number of changes, but the little ones are perfect when they leave the egg. They live on the seashore, clinging to the rocks, and enjoying themselves for some time before they go to their home in the hills.

Crabs exhibit some of the marvelous ways in which nature has protected animals by coloring and ornamentation. The backs of some of our commonest ones have a delicate tracery, like seaweed, covering the carapace or shell. It has

THE FIDDLER-CRAB.

the shades of the living algæ—light pink, red, brown, etc. The spider-crab is covered with a coarse, hairy fur. The hairs are serrate or hooked, and serve to collect and hold debris, in which tiny plants and hydroids find root-room and nourishment. Thus quite a garden often flourishes on the spider's shell, protecting him effectually from enemies.

Doctor Graeffe, who has spent a great deal of time in studying the crabs, tells about a specimen of *Maia verrucosa* which he kept. He removed all the vegetation from its back, then put it in a dish with "dead men's fingers" (a polyp). Soon the crab began to pull off the tips of the polyp branches with its claws. After letting them lie some time on the bottom of the dish, it carefully placed one at a time on its back, with the broken surface down. It seemed to know just which growths would bear transplanting in this way, and which would not.

THE HERMIT-CRAB IN THE SHELL OF A SEA-SNAIL.

A Swedish naturalist, Dr. Aurivillius, had a pet crab that supported a garden of bright sea-mosses. He put it among some sponges, when it removed with great labor all the mosses from its

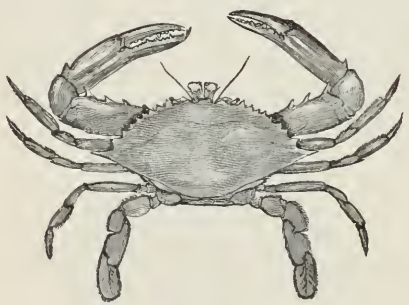
back, replacing them with bits of sponge. It put each piece of sponge up to its mouth, and appeared to lick it over before placing it on its shell. If any of the bits failed to adhere, they were licked a second time, and seemed to be covered with a sticky liquid.

The Japanese have a crab which they call "red crab of the devil," from its resemblance to their conception of that monster. It is fiery red and covered with fierce-looking spines. The lazy-crab, a slow-moving fellow, looks like a bit of pale-red sandstone overgrown with green sea-moss. In the East Indies lives a blood-red crab with a great white cross on his back and green stripes upon his sides.

The crabs, as a general rule, are dressed to match their surroundings. Those living in clear streams wear dark-green garments matching the plants about them; and some, living in Natal among yellow and orange mosses, are golden in color.

When the mothers and daughters are ready for their new garments, each retires into her hole in the sand, where the old dress is discarded and a new one donned. At first the new one is very soft, and it often takes some days for it to become hard and firm. When their toilets are all completed, the fathers and brothers take their turn and retire for some days, then emerge in shining new suits.

Some of the crabs have very queer habits. For instance, there is one family none of the members of which ventures out to walk without a parasol in the form of a dead leaf or empty shell, which it holds proudly aloft.



THE COMMON EDIBLE CRAB OF THE UNITED STATES.

The funny little fiddlers are rightly named *Gelasimus,* which means "laughable crab." It is sometimes the right and at others the left cheliped, or great claw, that grows so large it seems out of all proportion to the rest of the tiny fellow. The Japanese, who have always some poetical idea upon every subject, call the fiddler *Siho mancki,* which means "beckoning for the return of the tide." The fiddlers are in the habit of gesticulating with the great claw as if beckoning or drawing the bow across a fiddle. Those of my acquaintance have all been small, but there are some large ones that make burrows in the marshes and build over them little arches of mud. They sit beneath them and watch for their prey.

THE LADY-CRAB.

Many of the fiddlers live upon seaweeds. Professor Smith has seen them scraping up the sand on which their favorite food grows, making it into pellets, and carrying these into their holes, where he sometimes discovered large quantities stored for future use.

The hermits are very grotesque. The hinder parts of their bodies are so soft that they need some protection; so they search over the beach for empty shells. They try on one after another, until finally one of exactly the right size is found. They fasten themselves into the stolen shell with strong hooks which grow upon the ends of their bodies. Sometimes it occurs that two fiddlers. out house-hunting, happen upon the same shell at the same moment. Then there is usually a terrible battle, the victor walking off the field bearing proudly aloft his hard-earned home.

Some of the hermits have anemones growing upon the shells in which they live. Mr. Gosse tells of one which he kept in his aquarium. He separated the anemone from the shell inhabited by the crab; but before long he saw the hermit very gently take up the anemone and put it back on the shell, where it remained.

Many of the crabs are great scavengers, and if a dead shark is washed up on the beach it will not be long before hundreds are at work devouring it. If a person happens to pass near, or any little noise alarms them, they instantly disappear beneath the sand. When the danger has passed, hosts of funny little eyes on tiny stalks are protruded from the sand, and if things appear satis-

Top view. Under view.

THE KING-CRAB (OR HORSESHOE-CRAB).

factory their owners emerge and go back to the feast.

One of the hermit's big cousins, *Lithodes kamschatica,* which lives in holes in rocky cliffs, feeds upon the crab-eating octopus (devil-fish), thus in some measure squaring the account between the crabs and one of their enemies.

Some crabs are cruelly voracious. Many years ago a large steamer, the *Golden Rule,* with seven hundred passengers (among whom were my father and mother), was wrecked upon Roncador Reef, since become famous as the destroyer of our grand old *Kearsarge.* The people were taken to a small island near, where they stayed for ten days. When they lay down at night the crabs, with which the island was covered, came and bit holes in their clothes, in some cases even eating their shoes!

In Japan lives the "mountain savage," a great crab that has legs decorated with broad anklets of fur.

The crabs which spend most or all of their lives in the water are especially adapted for swimming. Some of the joints of their legs are compressed and flattened so that they are like little paddles. Among these are the American lady and blue crabs, which dart about in the water, chasing mackerel and other fish. They fasten themselves to the fish by their sharp pincers, holding on until it dies. Mr. Gosse saw many of the swimming-crabs in Central American waters. One was named the "velvet crab," and another had wonderfully beautiful iridescent legs. Some crabs are fitted for living in very deep water, and have suckers on their hind legs, by which they can cling to the rocks under the ocean and rest. Some deep-water crabs, taken from a depth of four or five hundred fathoms, had much shorter eye-stalks than the ordinary crabs, and the cornea (the horny covering of the eye) was wholly wanting.

Two very small crabs have a special interest on account of their curious homes. One is called *Planes minutus* (the little wanderer). It journeys about on the sargassum, the coarse though beautiful sea-plant that forms the Sargasso Sea, and sometimes it steals a ride on the back of a sea-turtle. It is supposed that it was this species of crab which Columbus spied on the sargassum and pointed out to his despairing sailors as a sign that land could not be far away.

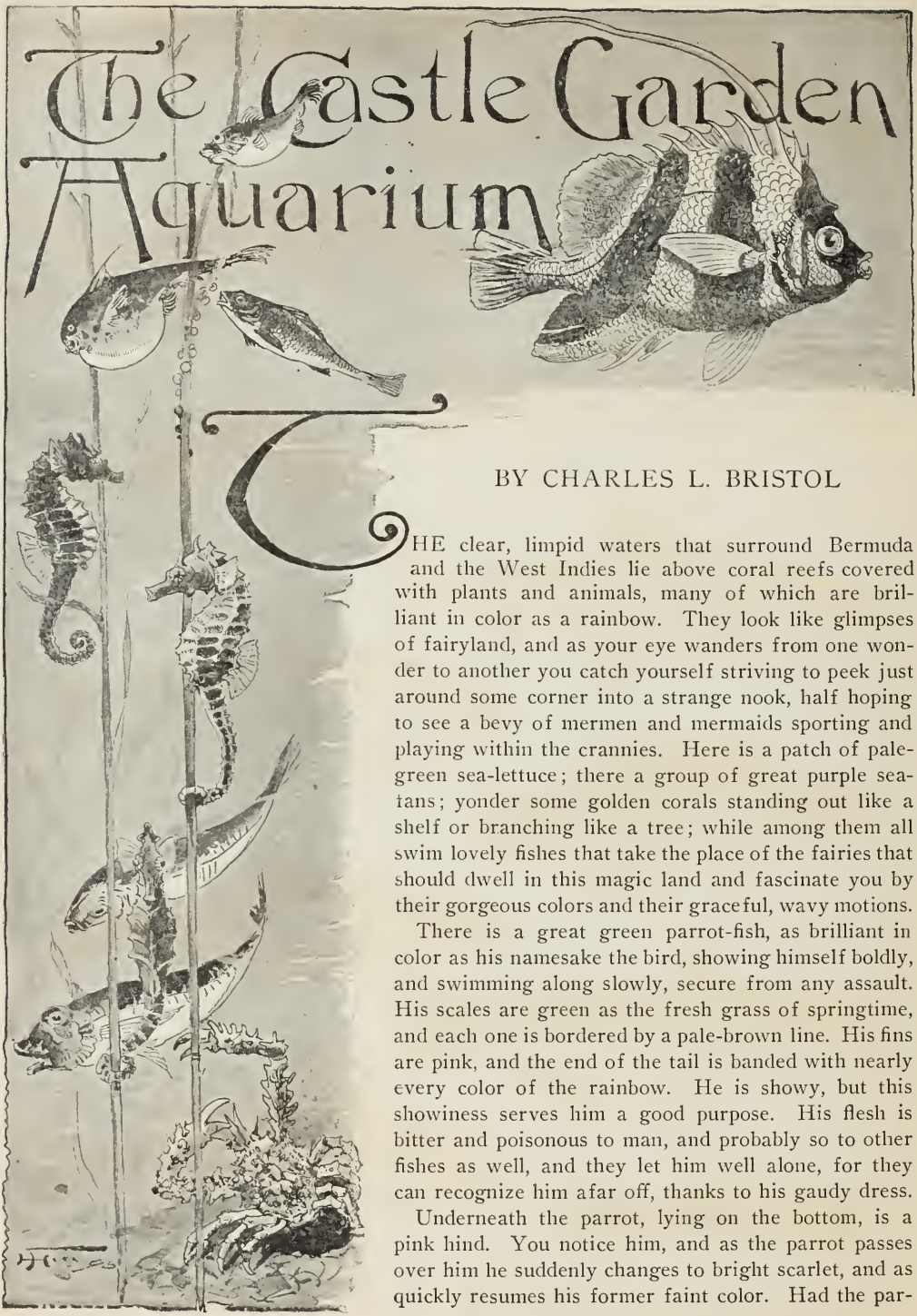
With the other we are all familiar. Who has not seen the tiny golden crabs in his oyster stew? This crab, which lives inside the shells of the oyster, pinna, etc., was called by Aristotle *Pinnoteres,* which means "one that guards or watches the pinna." The reason it received this name was because the ancients thought it warned the mollusk when any danger threatened. If a small fish accidentally got inside of the oyster's shell, he snapped it to, and then he and his little crab friend had a sociable meal upon it. The females of these crabs have very soft shells and need protection; so they take refuge inside the shells of the mollusks and live upon the refuse of their food.

The fiddler-crab has no musical ability, but another crab (*Melaplax*) is supposed to produce musical sounds, though I doubt if any one has had the pleasure of attending one of its concerts. It has what Dr. De Man calls "a musical crest" on the great claw. This is a horny ridge, and the music is made by rubbing it against a row of little knobs.

When the storm season approaches the shore-crabs bury themselves deep under the mud and sand, where they are safely protected from the fury of the great breakers that hurl themselves against the shores in winter.

The king-crab is a curious fellow. We might call him a second or third cousin to the true crab. His first cousins, whom he resembles strongly in many points, are the scorpions and spiders. The king-crab is a very old type, and, as it has an unusual amount of "grit," it has successfully battled against the hardships of existence; and those living all along our Atlantic beaches to-day are exactly the same as the fossil ones found in Silurian deposits. Instead of having five pairs of legs, as the other crabs do, it has six pairs, like the spiders. It is the only living relative of an immense race of trilobites that once peopled a large part of the earth.

Margaret Wentworth Leighton.

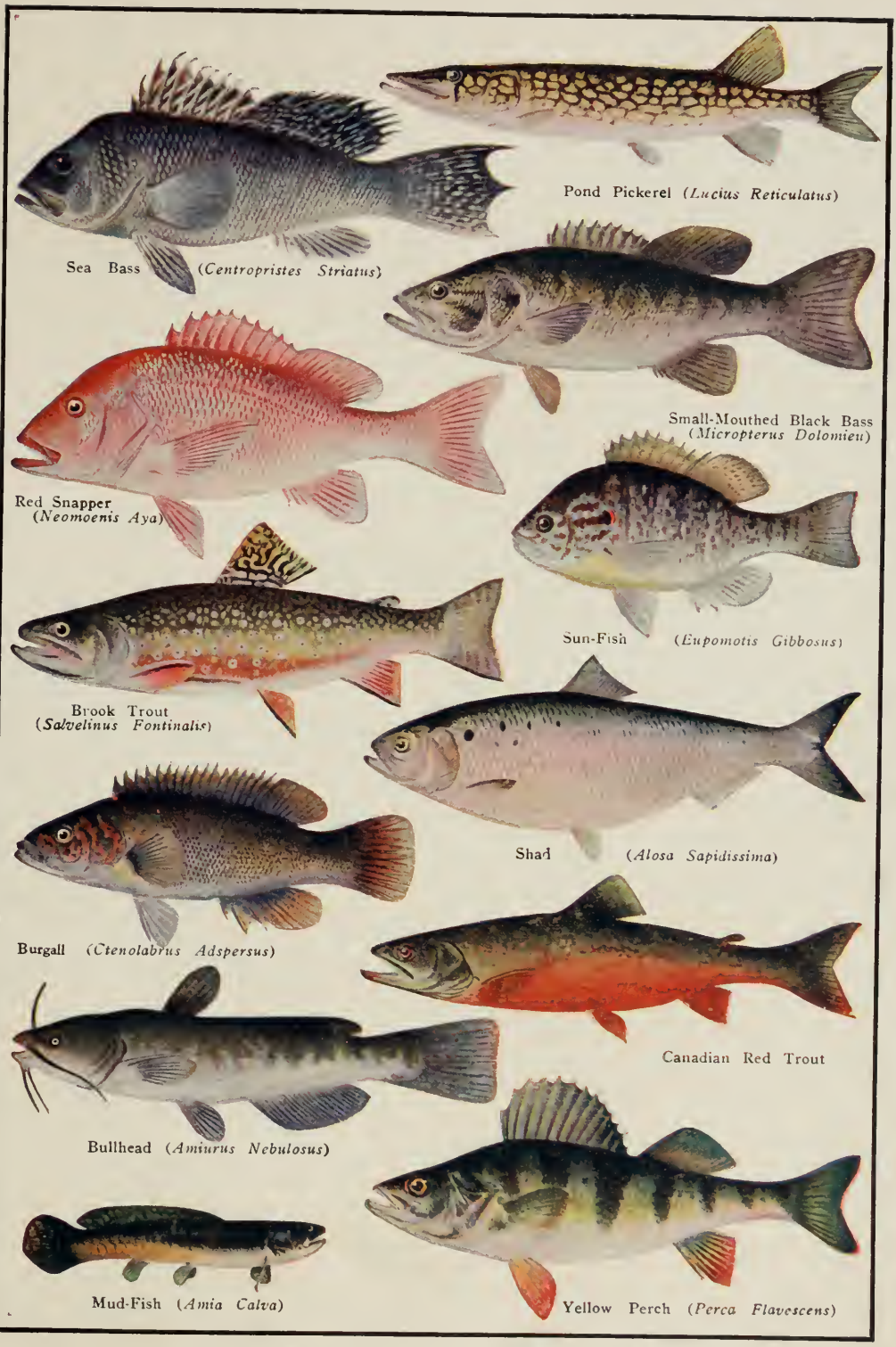


BY CHARLES L. BRISTOL

THE clear, limpid waters that surround Bermuda and the West Indies lie above coral reefs covered with plants and animals, many of which are brilliant in color as a rainbow. They look like glimpses of fairyland, and as your eye wanders from one wonder to another you catch yourself striving to peek just around some corner into a strange nook, half hoping to see a bevy of mermen and mermaids sporting and playing within the crannies. Here is a patch of pale-green sea-lettuce; there a group of great purple sea-tans; yonder some golden corals standing out like a shelf or branching like a tree; while among them all swim lovely fishes that take the place of the fairies that should dwell in this magic land and fascinate you by their gorgeous colors and their graceful, wavy motions.

There is a great green parrot-fish, as brilliant in color as his namesake the bird, showing himself boldly, and swimming along slowly, secure from any assault. His scales are green as the fresh grass of springtime, and each one is bordered by a pale-brown line. His fins are pink, and the end of the tail is banded with nearly every color of the rainbow. He is showy, but this showiness serves him a good purpose. His flesh is bitter and poisonous to man, and probably so to other fishes as well, and they let him well alone, for they can recognize him afar off, thanks to his gaudy dress.

Underneath the parrot, lying on the bottom, is a pink hind. You notice him, and as the parrot passes over him he suddenly changes to bright scarlet, and as quickly resumes his former faint color. Had the par-



A DOZEN FAMILIAR FISH OF NORTH AMERICAN WATERS.

Photos by Dr. R. W. Shufeldt

THREE NORTH AMERICAN FRESH-WATER GAME FISHES

(From top) Brook-trout; Large-mouthed Black Bass; Pike

rot been looking for his dinner, and thought the hind would make a good first course, this sudden change of color might have scared him off, just as the sudden bristling of a cat makes a dog change his mind. When the hind is disturbed at night he gives out flashes of light to startle the intruder and send him away in a fright.

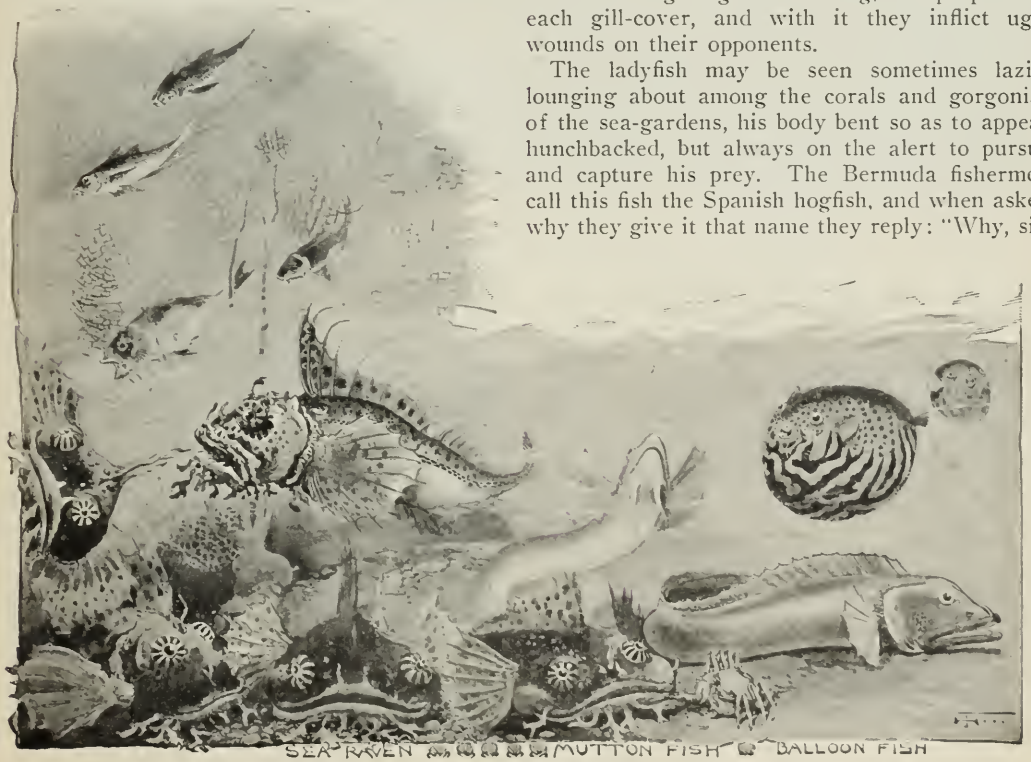
In a crack in the rocks, half hidden by the seaweeds, you may spy a speckled moray. He looks like one of our common eels, except that his dark-green body is flecked with bright-yellow spots, so that he is a handsome fellow. His name comes from the Latin *muræna,* an eel, and he has a famous relative—the great green moray—that grows to the length of eight feet. The green moray lurks among the caverns and crevices of the outer reefs in the deeper waters, darting out upon his prey with great speed. The wealthy Romans of ancient times, who had villas on the seashore, esteemed the flesh of the green moray as a dainty food, and they constructed great pools in which to confine them while they fattened them for the table. Pliny relates that a certain man named Hirtius provided six thousand dishes of moray flesh for his friends at Cæsar's triumph. One Crassus was so fond of a great moray which he had in his tank that he decked it with golden ornaments, and actually wept when it died. These epicures fed them on chickens or pigs or sheep or other food in their rivalry to produce a new flavor. The ferocity of the morays was well

SPECKLED MORAY.

known then, for we find allusions to threats to throw disobedient slaves into their pools.

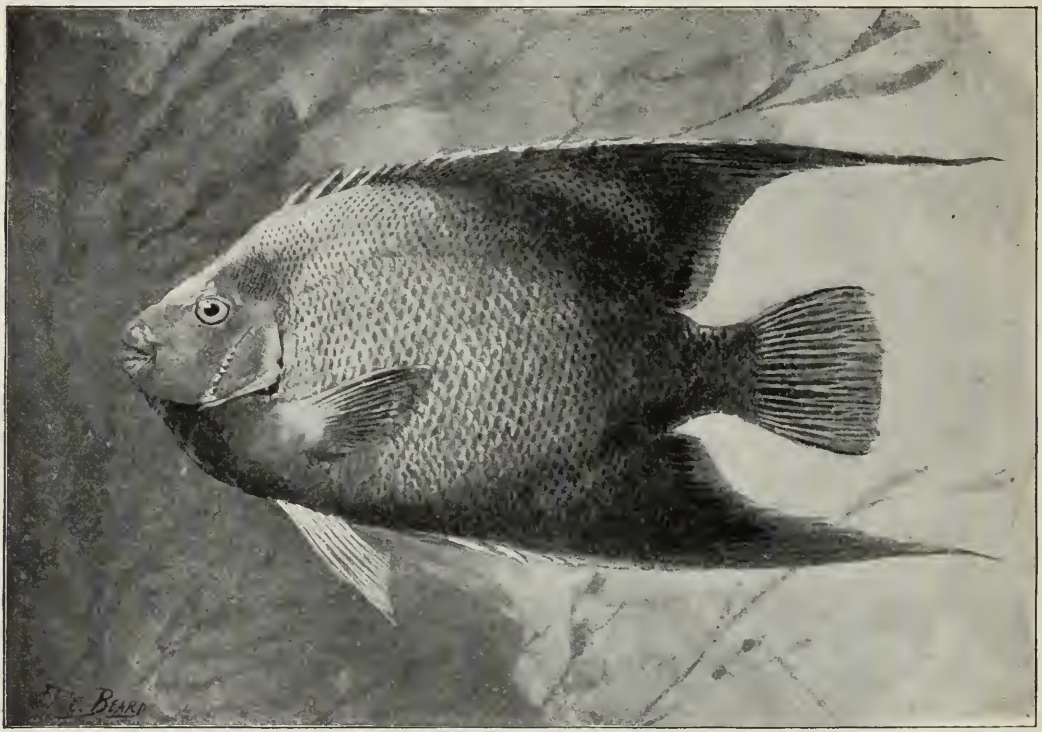
Swimming out boldly like the parrots are the most attractive of all the bright tropical fishes, the angel-fishes. They are easily distinguished by long streamers of golden yellow and a beautiful blue stripe along the back. They are graceful, too, swimming now on one side, poising themselves in the surging water at the top of the reef, or now sliding out of sight into some crevice of the rocks as if by magic. But they are angelic only in appearance. They pester other fishes continually by nibbling at them, and if they set out to fight, they usually win. They are armed for fighting with a long, sharp spine on each gill-cover, and with it they inflict ugly wounds on their opponents.

The ladyfish may be seen sometimes lazily lounging about among the corals and gorgonias of the sea-gardens, his body bent so as to appear hunchbacked, but always on the alert to pursue and capture his prey. The Bermuda fishermen call this fish the Spanish hogfish, and when asked why they give it that name they reply: "Why, sir,



you see it lazes around just like a hog, and it carries the Spanish colors."

The reason is good, for the fish is brownish red from his head to the middle of his body, and from there to the end of his tail a bright yellow.



THE ANGEL-FISH.

It is not necessary to go to Cuba or Porto Rico or to Bermuda to see these beautiful fishes, for the city of New York has a large aquarium where all of those described and a multitude of others may be seen without cost on any day between nine and four o'clock. It is situated in Battery Park, at the southern end of the island of Manhattan, within easy reach of all the ferries and the elevated railroads. The building, which was built for a fort, near the beginning of the last century, is circular in form, and as you enter, the whole arrangement of the exhibit is plainly seen. On the floor are six large pools ranged around a larger central pool, and in the walls are the tanks, whose fronts appear like so many beautiful living pictures. The thick plate-glass of these tanks is so clean and clear that it is invisible, and one feels, as he looks into them, that he is walking about in the submarine world. On the main floor there are thirty-six of these tanks, and in the gallery floor above are fifty-six more, making in all, with the pools, the largest aquarium yet constructed anywhere.

The pools on the floor receive the large water animals, such as sharks, seals, whales, and sturgeons. It would be hard to say which pool is the most interesting. There are of course the ever-interesting seals, while sturgeons and anglers claim a good deal of a visitor's attention. The angler is a curious-looking fish, almost flat, with broad fins and a wide, flat head that makes up nearly three fourths of the bulk. It is reddish brown in color, and mottled so as to resemble the common rockweed of the ocean, and all along the edge of the body the skin grows out so as to make a ragged fringe. Its mouth is a huge affair, so large and cavernous that a fish of medium size could easily take in a large pie at a gulp. On the end of its nose are two or three long spines, and on the tips of these are little tassels of flesh. The name angler was given to the fish because it half buries itself on the bottom among the weeds so that it is concealed, then plays the little tassels in the water before its mouth to lure the unsuspecting fishes near enough to engulf them in its capacious maw. Here is a veritable fisherman fish! It lives along our Atlantic coast in some-

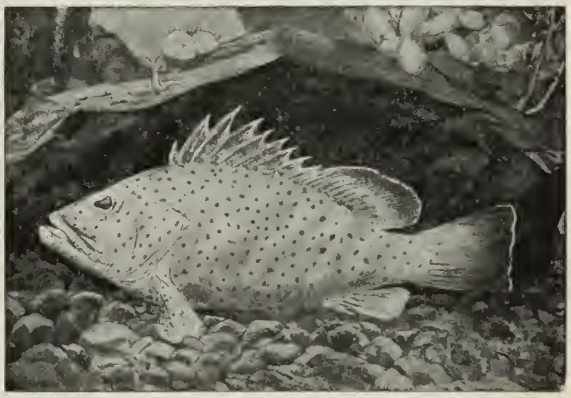
THE MOONFISH.

what deep water, and may grow to reach a large size. There are other fishes that angle for their dinner, and one in the Mediterranean Sea, the star-gazer, runs a long, worm-like tongue out of its mouth, which it wiggles and twists like a worm. The little fishes rush greedily to seize it, only to find that they have run into a trap from which there is no escape.

The wall-tanks on the right side as you enter are devoted to fresh-water specimens, and those on the left to salt-water specimens. Among the fresh-water fishes are many that are familiar to every boy who has wet a hook. Here are bull-heads, "punkin-seeds," yellow perch, pickerel, suckers, several kinds of bass, and a large display of the royal family of the lakes, streams, and brooks—the trout family.

On the salt-water side may be seen the beautiful tropical fishes from Bermuda, and many more kinds besides. One tank is filled with lobsters, blue crabs, spider-crabs, horseshoe-crabs, and others. Here are some sand-sharks with sullen, ferocious looks, and along with them are the pilot-fish that swim around with the sharks just as they do in the ocean, expecting to gather up the crumbs of the sharks' next meal. The moon-fish, in another tank, is, perhaps, the weirdest of all the fishes in the Aquarium. It looks as if made of burnished silver. The body is thin from side to side, but wide from top to bottom, and the long fins reach above and below like wands.

Among the warm-water fishes that make their way up along the coast during August and September is one known as the cavally, or crevallé. It belongs to the mackerel family, and is found in both the Atlantic and Pacific oceans. It has a blunt head and a short tail, and is bright golden in color. It is excessively timid, and never becomes wonted to a life of captivity. These fish



THE SPOTTED HIND.

swim about in a bunch, and are constantly in motion. The night watchmen have often tried to come upon them stealthily to see if they are ever quiet, but so far they have been found circling as in the daytime. One day some thoughtless person flung a handkerchief at the glass front of the tank, and that night every cavally was dead from fright. Its name comes from the Spanish *caballo,* a horse. On our coast it has gained the name of horse-mackerel.

I have not attempted to mention most of the interesting aquatic animals, nor even all the rarest and most peculiar. A list would require a good-sized book, for there are more than two hundred and fifty different kinds on exhibition. There is, however, one feature of the exhibit that must be mentioned. The fishes and other aquatic animals have been collected from a very wide geographical range—from the Great Lakes, the Mississippi Valley, the West Indies, the rivers of

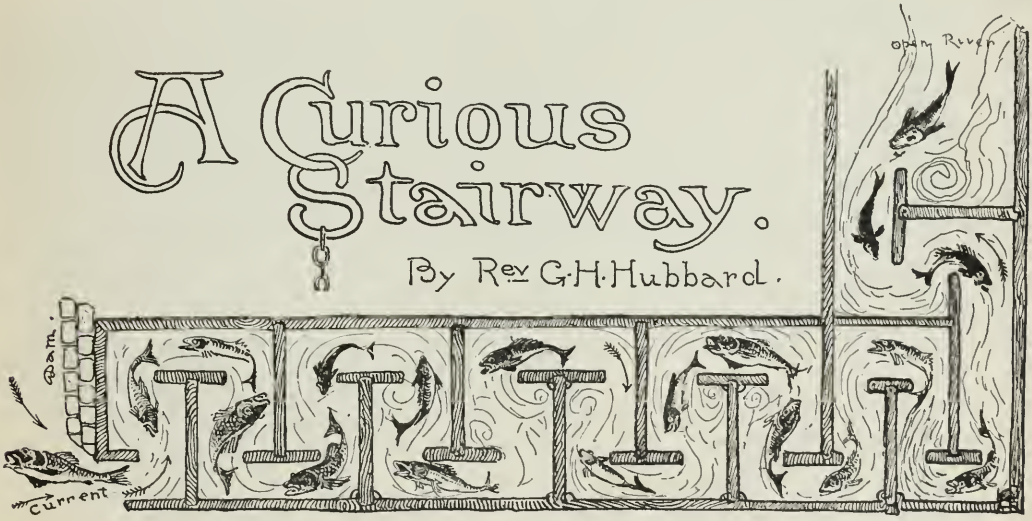
THE GREEN PARROT-FISH.

MOONFISH.
PORGY.

Maine, and the Gulf of St. Lawrence. No other aquarium pretends to collect fishes beyond a few miles from its doors, while here distance is no barrier to the exhibition of a beautiful or interesting specimen. And the numbers and varieties are increasing all the time.

A Curious Stairway.

By Rev G. H. Hubbard.



It was early in the month of April, and Fred Kent was spending a few days with his uncle in Taunton. Fred's home was in a village among the mountains in New Hampshire, and, being only ten years old, he had not often traveled. This was his first visit to the State of Massachusetts, and he saw many things that were interesting.

One fine, warm day, his Uncle James drove up to the door, and said, "I 'm going to drive into the country on business this morning. Would you like to go with me, Fred?"

Fred said he would, and went into the house for his hat.

"Where are we going?" Fred asked as he scrambled into the buggy.

"To Squawbetty," replied his uncle.

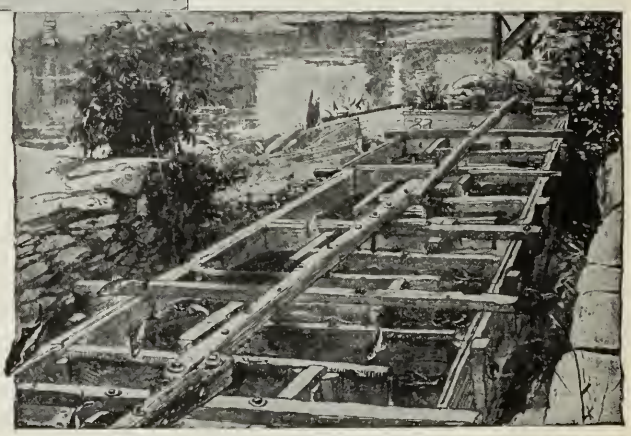
"Squawbetty!" echoed Fred. "That 's a funny name for a village! Where in the world did they ever get such a name?"

"The name is n't so strange," was the answer, "when you know how it came to be given. When the town of Taunton was first settled, the land in what is now its east part was owned by an old

Indian squaw named Betty, and was known as 'Squaw Betty's Land.' Later it was purchased by the settlers; but it has ever since borne the name of Squawbetty. Once there were large iron-works at the village; but they were burned down years ago. The village is a quiet place now. At present the only object of interest is a curious stairway that I am going to show you."

"Is it a stairway in one of the early settlers' houses?" said Fred. "I have read of hidden stairways in old castles, by which persons used to escape when the castle was captured. William Wallace had one leading to an underground passage that went from his home to an old monastery near by. Did the settlers of Taunton have such stairways to escape from the Indians?"

"Oh, no," said Uncle James, laughing at the notion. "This stairway is more curious than those; and it is out of doors, where everybody can see it."



TWO VIEWS OF THE FISHES' "STAIRWAY" AT SQUAWBETTY.

"I guess I know what the stairway is like, then," Fred went on, for he was fond of guessing. "It can't be any more wonderful than one I saw once near home, cut out of the solid rock. We were having a picnic where the river runs in a deep cut between two high rocks, and the only way to get down to the riverside was by steps cut in the cliff. I guess your stairway is something of that sort."

"You will have to guess again, and then you won't guess right," said Uncle James mysteriously, but with a smile. "The stairway we shall see is made of wood, and it was built for the fish, so that they could make their way upstream over the dam."

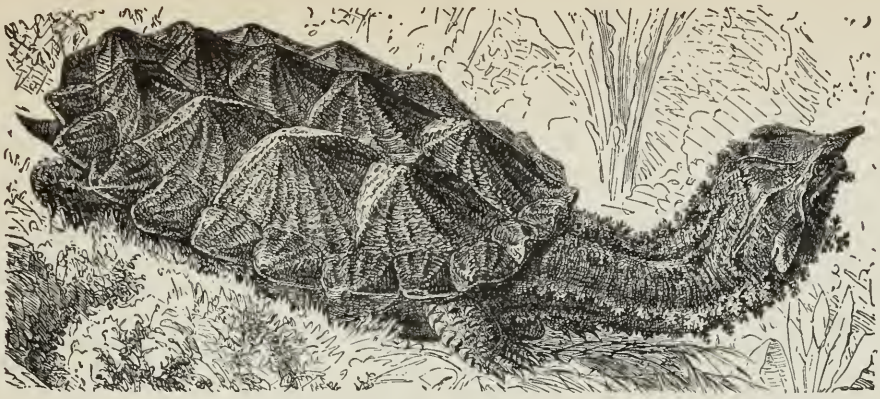
"You must be making fun of me," said Fred. "I know that fish cannot climb stairs. And, besides, they don't need to. There are no stairways in our streams in New Hampshire, and there are a great many fish in them. I have often caught plenty of fish just above a high fall in one of the brooks on my father's farm."

"No," persisted Uncle James, "I am not making fun of you; I mean what I say. The fish in your streams at home are trout and other strong swimmers that can go up the swiftest rapids and falls without help. But herrings and alewives are not good swimmers. They are found only in streams that have no natural falls. Every year great numbers of them come up from the salt waters to hatch their eggs in the ponds of Middleboro. Many of the people who live near the river depend on the herring-fishery for their livelihood. When the dam was built, it was found that the herring could not go up as usual, and as that would bring a serious loss to the people, the mill-owners were compelled to put in a stairway."

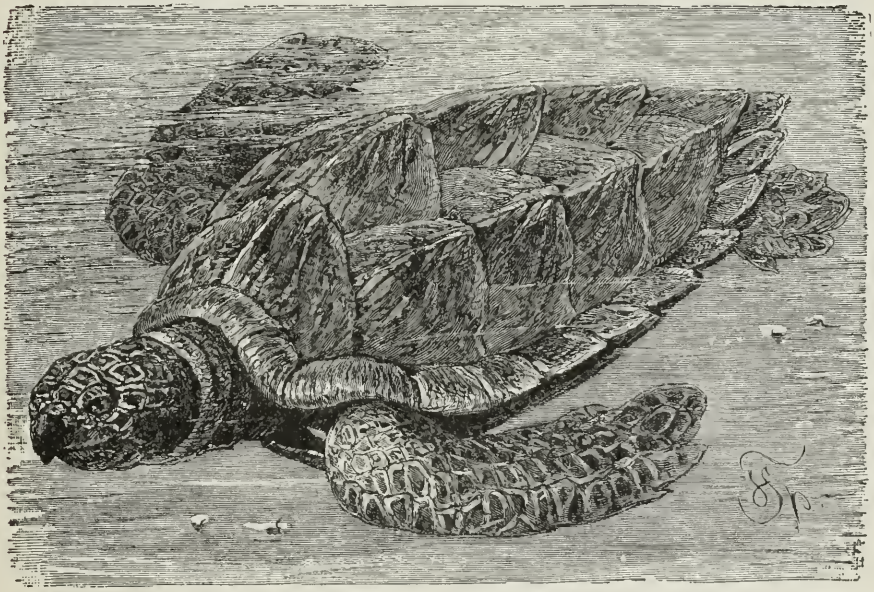
"What is it like?" asked Fred.

"You can see for yourself in a few minutes."

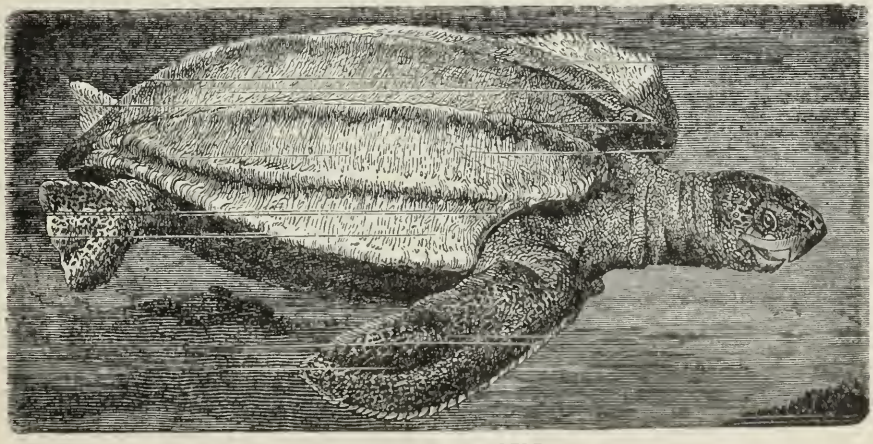
They soon reached the village of Squawbetty, and after hitching his horse to a convenient post, Fred's uncle led the way through a large gate near a bridge into what had formerly been the foundry yard. Not far from the gate there was a dam across the Taunton River, and only a few feet above the water a row of small buildings extended the entire length of the dam. They entered this building, or row of buildings, and as



MATAMATA.



DIAMOND-BACK TURTLE.



LEATHER-BACK TURTLE.

they walked along they could look down between loose planks into the water below. In some of the quiet nooks they saw hundreds of fine herring swimming about in search of an easy passage upstream. Fred had never seen so many fish before, and he wanted to stop and watch them; but Uncle James told him this sight was nothing to what he would see further on.

Then they walked out on the stone dam of the new mill, and Fred was wild with excitement when he saw the smooth water below densely crowded with herring so close to one another that there was little room to swim about. And when some bigger fish, like a shad, broke through the crowd, he could see that they were in an almost solid mass of one or two feet in depth. "How I would like to fish here!" said Fred. "Yes," said a man who was standing near, "I would give a thousand dollars for the privilege of fishing from this dam; and it would be cheap at that, too."

After a few minutes Uncle James said, "Come, let us go over to the other side of the river."

Returning through the buildings to the opposite bank, they found a crowd who were watching something with great interest. What that something was, Fred could not at first see.

"Where are the stairs you told me about, Uncle?" he inquired.

"Here they are," said his uncle, going down to the bank of the river. As Fred followed, he saw a long wooden box, or trough, extending from the top of the dam to the level of the river below, with a gradual slope. This trough was about two feet deep, ten or twelve feet wide, and perhaps seventy-five or a hundred feet in length. Across the trough were placed stout planks, six or seven feet long, the first fastened to the right side, the second to the left, and so on, with short cross-pieces at the free ends. Thus the water, as it came from the dam, instead of flowing down the trough in a straight course, was forced to wind about the ends of the cross planks from one side to the other, breaking the swiftness of the current, and leaving quiet pools in all the corners.

But Fred scarcely thought about the trough at all; for the herring were coming up in such numbers that the stairway seemed to be almost one solid mass of fish. Not a few in their struggles to get upstream actually jumped over the side of the trough and fell on the ground.

A man who said he had always lived near by told Fred that he had seen the trough so full of fish that one might walk over on their backs. Fred was ready to believe anything after the wonders he had seen; but Uncle James laughed, saying it would do very well for a fish story. Fred could easily have caught some of the fish in his hand; but an officer who was always on the watch told him that there was a fine of five dollars for doing so.

"Why is that?" asked Fred.

"Because if the people were allowed to catch them, the fish would be frightened and would not come up the stairway, and soon the herring would entirely disappear from the river," Uncle James explained.

When they reached the city, Uncle James took Fred to a store where they sold silverware, and showed him a "Taunton spoon," with the Brick and Herring on the handle. He told Fred how in the early days the people of Taunton made their money chiefly from the herring-fisheries and the manufacture of brick. Indeed, at that time, if a vessel from Taunton was sighted anywhere, other captains knew without asking that she was loaded with brick and herring!

THE SMALLEST LIVING THINGS

MICROBES

We have to talk now about the simplest kinds of living creatures that we know, and about the things they do, not only because they are very interesting in themselves, but also because their life affects the story of the earth, which they are constantly changing in many ways.

These living things, so extremely small, have many names, and are often called *germs*. You have perhaps heard about germs already, as this is the name applied to these things when they make us ill, as they often do. They are then called the germs of disease. But the great Frenchman Pasteur, who found out that some of these things often make us ill, called them *microbes,* a word which really means small life, and which tells us that we are talking about living things of very small size.

Since they so often make us ill, most people think that all microbes are evil, and that there are none which are of any use. Now, we want you to learn that really these microbes, which men discovered only in the last century, are necessary for all the life of the earth, including our own. It is only a very few kinds of microbes, really, that make us ill, and can therefore be called the germs of disease. By far the greater number of the microbes are not merely perfectly harmless to us, but we could not live without them. It is well that we should learn, as soon as possible, that these wonderful little creatures exist, and that they play a great part in the story of life and of the earth.

The first thing to learn about microbes is that, as we have said, they are very small—so small that unless we have some way to help our eyes we can never see them; and, indeed, some people believe that there are many microbes so small that, however much we help our eyes, we cannot see them.

Men, therefore, could not know that microbes existed until the invention of the wonderful instrument called the microscope—an arrangement of pieces of glass in a tube, which magnifies small things, so that we can see them. Yet even the microscope would not be sufficient alone to show us how many kinds of microbes there are, and to teach us that they are almost everywhere.

When we say everywhere, we do not mean that you can find microbes in a fire—because, of course, they cannot live there. Neither will you find many microbes in the air if you go far out to sea in a ship and examine the air there; but you will always find microbes in the earth. They abound in ordinary air, they are on everything you can touch, in the house or out of doors, and they have even been found in the snow in the arctic regions. They are to be found in all water. So, practically, they are simply everywhere—tiny living creatures, living their own lives, and in consequence doing things all the time. It would be very bad for us if they were all hurtful to us.

HOW YOU CAN WATCH THE MICROBES GROWING

There are still a few people who are inclined to think that microbes do not exist; but that is simply because these people have never taken an opportunity of seeing them for themselves. But really this is quite easy, and there is no doubt that the little things are alive, because you can see them moving about.

It is also a very easy thing to grow microbes. You may take a few just by dipping the point of a needle in something containing them, and then you may put them into some milk—one of the best things for growing microbes in—or in a little beef jelly, or you may stroke the needle across the cut surface of a potato; and in these and in many other ways you can watch microbes growing from day to day. Of course, you cannot see the separate microbes, but you can see the colony of them as a whole, and, as different kinds have different ways of spreading, any one who knows them can pick up the tubes in which they

are growing, and say what kind of microbe a tube contains.

THE LITTLE CELL THAT DOES ALL THE WORK OF LIFE

In some ways all microbes are very easy to understand, because they are so very simply made—that is to say, they look simple and they are very easy to describe; but then there are thousands of different kinds of them, though most of them look so much alike, and these differences must depend upon differences in the way in which they are constructed. These microbes are too small for us to see this, but, so far as we can see, they are all made very much alike.

Every microbe simply consists of one little piece of living matter, called a cell. That is its whole body, and does all the work of a living creature for it. Some microbes are round, and some are like little short rods; some are very thick, and some, like those which cause influenza and consumption, are very slender; but all microbes, whether harmless or dangerous, and wherever they live, consist of one cell, as it is called.

It is very important to realize that a complete living creature, which moves and grows, can do these things, even though it has no mouth or lungs or muscles. We have to learn that many of the things we do by means of many different parts of our body made specially for the purpose can be done by living creatures that simply consist of a single living cell, which, so far as we can see, is the same throughout, and in which no different parts at all can be observed.

Many names are given to microbes according to their different shapes, but these do not matter for us; and, indeed, for some reason or other, many microbes take different shapes at different times.

When they are growing in one place, perhaps they are round or very short, but when they are growing in other surroundings, they may become long or thin. This is very likely a question of the kind of food they get, and it reminds us that the people who grow up in the slums are usually very short, while people who have good food and grow up in fresh air are generally many inches taller.

Considering the great things they do, the smallness of microbes is wonderful. A fair average size would be one-twenty-thousandth part of an inch across. If you could take some of the little rod-like microbes and place them end to end, nearly ten millions would be required to reach a yard, and many thousands of billions to make a solid cubic inch.

This, were it not so overpowering, would give us some idea how tiny these tiniest of living things are; and we should not forget that there may be many others which are tinier still, so that we cannot even see them with microscopes, which are able to make a thing look ten thousand times as long as it really is. When a microbe has reached its full size—though that is not much to boast of—it does not stop feeding and growing, but it splits into two. Now, there must be some reason why a living cell, which is quite strong and young, and has plenty of food, never goes on growing and growing without limit, but always after a certain point either stops growing altogether, and gets no bigger, or else splits into two cells. A great philosopher, Herbert Spencer, found out the reason.

HOW STRANGELY ONE LIVING THING BECOMES TWO

When a thing is very tiny, it has a large amount of surface compared with the amount of stuff in it. A much larger thing has, of course, a larger surface, but as a thing gets bigger—and it does not matter in the least what you take—the size of its surface does not increase nearly so fast as the amount of stuff in it. Now, it is, of course, through its surface or its outside that a living creature gets its food, and for every living cell the time comes when its outside is not big enough, in proportion to the amount of stuff inside, for enough food to pass through it.

So, when this point is reached, a living cell must either stop growing or it must split into two cells. These two cells, you see, will have just the same amount of stuff in them that the one cell had, but they will have between them a much larger amount of surface than the one cell had, and so they will be able to get enough food to keep them going and growing. After all, it is just the same as the case of an animal like an elephant, which is very big, and must therefore have a big mouth. The surface of a living cell is its mouth, and when the inside of a cell gets too big, its surface, or mouth, does not get big enough in proportion.

This, then, is why a living cell, like a microbe, always splits into two when it has reached a certain size, and, as this law is true of all living cells, and as all creatures are made of cells, it is one of the most important laws in the world.

The rate at which microbes grow and multiply can scarcely be believed. Starting with only one microbe, and giving it sufficient food, in only twelve hours we should have something like eighteen millions, and six hours later we should

have nearly eighty thousand millions. All this would simply be the result of taking in food, growing and dividing, and repeating the process at a tremendous rate. Of course, we do not say that this ever happened, for there would never be sufficient food, and, indeed, if microbes could get enough food to multiply as fast as they are capable of multiplying, they would soon be the only kind of living things left on the earth at all. As it is, they are like the rest of us, they cannot grow unless they get enough food of the right kind, and this is far from always being the case.

Microbes grow at rates something like this when we cultivate them on purpose, and give them the kind of food they like best; and also, unfortunately, they multiply at rates like this sometimes when they attack us, and make us ill, especially in the case of people whose bodies are just suited for microbes to grow in.

MICROBES, REALLY TINY PLANTS, LIVE LIKE ANIMALS

But you must quite understand that not many kinds of microbes can grow in our bodies at all, and that most of them are killed at once when they enter our bodies. It is also well to remember that there are certain kinds of microbes which our bodies will kill at once, if we take care of our health and live sensibly, but which may kill us if we have been doing foolish things, and so have lessened our powers of protecting ourselves from these enemies.

The various shapes of microbes, we have said, matter very little, but what does matter a great deal is the two different kinds of ways in which microbes feed, and this we must very carefully understand. Microbes belong, on the whole, to the vegetable world, rather than the animal world, but though they are really tiny plants, none of them contain any of the green matter which enables plants to live on air as well as to breathe air. Therefore, so far as their feeding is concerned, microbes are in the same position as animals. They are all compelled, like animals, to live upon food furnished them by the bodies of other living creatures.

This is the great mark of microbes—that they live upon the bodies, either alive or dead, of other living things. These may be animal or vegetable, just as we may eat beef or bread. The great distinction between microbes is that some of them live merely on the dead remains of living things, while others will attack and feed upon other creatures, animal or vegetable, while they are still alive.

MICROBES THAT PLAY A GREAT PART IN THE WORLD

There are long names to describe these two kinds of microbes, but these do not matter. Those which live upon other creatures still alive are not nearly the most numerous. They include those which cause many diseases in mankind, and also attack at times other living creatures, too. But here we want especially to speak about those much more numerous microbes which live on dead matter, though always matter that has once been alive. These play a great part in the world, and, indeed, we could not possibly live without them.

Consider how many countless millions of living creatures, human, animal, and vegetable, are upon the earth, and in the air, and in the sea at this moment. For untold ages this has been so. Yet, as we know, these creatures die, and those who came before them have been dying in countless numbers every day for ages past. Now, if we consider for a moment, we shall see that, if there were no means by which the bodies of all these creatures were disposed of, the earth must long ago have been heaped up with them.

The truth is that life simply could not go on if there were not something at work which, all the time, is taking the bodies of plants and animals, as they die, and doing something to them, so that they simply disappear, and are got out of the way. But more than this, there is something at work which takes these bodies—in themselves dangerous and disagreeable—and turns them into simple materials which are used as food by the new creatures living at any time.

HOW MICROBES HELP TO KEEP THE WORLD YOUNG

We know that microbes take the dead leaves in the autumn and turn them into stuff which can be used for making new leaves in the next spring. Microbes, then, are the wonderful organisms that do for the dead bodies of all once living things what they do for the dead leaves. They keep the world young and fresh and green. It has very often been said that they are scavengers, meaning that they are like the men who keep the streets clear of refuse. Microbes do this, it is true; but that is only the beginning of their work, and not nearly the most wonderful part of it. Far more wonderful is the way in which, living their own lives, they take things which would be disagreeable, or which, at the least, would be useless and cumber the earth, and, without noise or

disturbance or any help from us, turn these things into the sources of new life.

We have to learn that there is really nothing useless in the world. Microbes are the humblest kinds of living creatures, but they are not contemptible. Without the work they do in the course of their humble and unnoticed lives, no higher form of life upon the earth, vegetable or animal or human, would be possible.

TINY CREATURES THAT HELP LIFE TO RENEW ITSELF

Without them the earth would long ago have become simply a heaped-up graveyard; but by their aid life can go on renewing itself from year to year, and will do so for countless ages to come. Yet these wonderful little creatures, without whose aid none of us could live here, were not discovered till after the middle of the last century. Things may be so small that we cannot see them, but they may yet be more important than the biggest mountain on the face of the earth; and no one knows what things there may be which no one has even guessed at, but which may be just as important as anything we know.

We can get some idea of the unceasing way in which these microbes are everywhere doing their work if we examine ordinary earth, and find how many microbes it contains. One grain of ordinary earth will contain anything from one thousand to three hundred thousand microbes, their number being greatest in earth in which many plants are growing. If you think of the thousands of microbes in a single grain of earth, and if you think how tiny that quantity is, you will begin to realize that it is not possible to say how many microbes there are in the world.

OUR UNSEEN FRIENDS AND FOES

Different kinds of microbes have different powers. Some will break down one kind of plant, some another. There are kinds of microbes in the earth which have special powers of making food material with the aid of the air which is found in the earth. Air contains a very valuable element, called nitrogen, which ordinary plants cannot use, and which we cannot use, though we breathe it into our blood along with the oxygen which we *do* use. But certain microbes can take this nitrogen and combine it with other elements so as to make compounds which are perfect food-materials.

Within the last year or two these special microbes have been purposely cultivated in the places where men of science work, and can be put in bottles and sent by mail, and then sown, so to speak, in a field, so that, when the farmer comes afterward to sow his wheat, these microbes will be ready there to provide the young wheat with the best food.

These particular microbes are specially fond of certain kinds of plants belonging to the tribe of peas which are not particularly useful in themselves; but the farmer knows that it is worth his while to grow these plants one year, so as to make the soil rich in food for his wheat in the next year. If he grows wheat every year, the soil will become exhausted of its food-materials, and so farmers have long practised what is called the rotation of crops. It is, of course, a very serious matter, for the farmer and for the country, that the farmer cannot grow wheat every year. But now we think our discovery of microbes, and of what they do, is going to prove of the greatest value before long in actually making bread cheaper. It is hoped that, by using these special microbes in the way we have described, we may soon be able to grow wheat, year after year, in the same soil.

The dairyman should really be no less interested in microbes than the farmer should be, for they are of the utmost importance in all his work. Among them are included his best friends and his most dangerous enemies. If we realize that microbes are everywhere, we shall understand that they invade milk from the very moment that it is drawn—microbes of all kinds, useful and dangerous, from the air, from dust, and from water. Now, milk is one of the best things in the world in which to grow microbes, and so those which get into it grow very quickly, for good or for evil. It is the duty of the dairyman to keep out of his milk, as long as it is in his charge, all dangerous microbes.

It is the duty of every one who is in charge of milk to know that this, which is a perfect food for us, is also a perfect food for some of our most terrible enemies, such as the microbe that causes consumption, and the microbe which kills tens of thousands of little babies every summer.

MICROBES THAT GIVE US MEDICINE

But here we are talking especially about the natural and proper work of microbes. Now, there are quite a number of them which are, in a sense, natural in milk, and are indeed known as milk-microbes. We do not say that they are found in milk when it is drawn, but they are certain to enter it, and they are indeed very useful in it.

These microbes exist in enormous numbers in cow-stables, and they always get into milk very

soon after it is drawn. Now, the extraordinary thing about this is that as they grow and multiply in the milk they prevent other microbes, which might be bad for us, from growing there. In course of time they turn the milk sour, but sour milk is not bad for us, and, indeed, the microbes in sour milk, when they enter our bodies, help to protect us from other microbes which might do us harm. So they are really very good friends of ours, and nowadays, when people suffer from certain kinds of illness, they are purposely given sour milk in order to make them better. The microbes in sour milk help us to digest our food, and they prevent other microbes, which would hurt us, from multiplying in our food after we have swallowed it.

MICROBES THAT HELP US IN VARIOUS WAYS

But there is more to say than this. From milk we get cream, and from cream butter, but without the proper microbes of milk butter could not be made at all. It is the milk-microbes which cause the cream to ripen, as it is called, so that butter can be made from it. That is one of the reasons why we said that some microbes were good friends of the dairyman.

The different flavor of different kinds of butter depends on the particular kind of microbe that ripened the cream from which the butter was made, and nowadays we can cultivate, quite easily, just those kinds of microbes which help us to make butter that has the kind of flavor which people like. As the microbes start the process of butter-making, they are called "starters," and in many parts of the world men of science supply the best kind of "starters" to farmers to ripen their cream with.

Just as we could not have butter without microbes, so we could not have cheese. All cheese, of course, is really made from milk, and the milk produced by any particular kind of animal, such as the cow, is the same all the world over. Yet there are dozens of different kinds of cheese, and their differences mostly depend upon the particular kind of microbe which has been used—whether people know it or not—in making the cheese. These, too, are now cultivated, and by sending tubes or bottles of them anywhere, you can enable the people there to make the particular kind of cheese usually made far away from them.

Besides butter and cheese, there are various special preparations of milk made in some parts of the world, some of which are very valuable when people are ill, since the body, even when ill, can use them easily as food. All these special preparations of milk owe their existence to microbes.

We owe our boots to microbes, too. Boots, you know, are made of leather, and all leather is made from the skins of animals by a process called tanning. But tanning would be impossible without microbes; so that we owe our boots to them as well as cheese and wine and cigars. Then they are used in preparing the dye called indigo, and in preparing many kinds of food for cattle, and we even owe some kinds of clothing to microbes, for without them it would hardly be possible to spin linen out of flax. Nor is this all.

Every great city has to deal with the problem how to dispose of its waste matter. The old way was—if the city were on a river—simply to pour the sewage into the river and let it poison the people of cities farther down who drank the water of the river. We are afraid that a great deal of that goes on still, but it is dirty and it is deadly, for it destroys much human life.

We are slowly learning now, however, that there are ways of dealing with sewage which make it more or less harmless, and one of these ways is by using microbes. Now, it is the bad microbes in the sewage which make it so dangerous, and so the use of other microbes, to make the sewage harmless, or to get rid of it, is rather like the old principle expressed in the proverb, "Set a thief to catch a thief."

We see now that these tiniest of all living creatures play a great part in the world. But after all that has been said about wheat and butter and cheese and boots and linen, and so on, we must understand that all these useful things which microbes do are really quite unimportant compared with the first thing we talked about—the marvelous way in which they clear the earth of the bodies of all dead creatures, animal, vegetable, and even human, so as to make room for those who are now living and those who yet shall be; and, more than that, turn the stuff of which these millions of dead bodies are made into fresh, wholesome, and pure food material to nourish the life of the earth.

THROUGH THE MICROBE PAST LIFE MAY LIVE AGAIN

You know what economy means? Literally, it means the "law of the house," by which everything is done in order, everything has its use, everything is put to the best purpose, and nothing is wasted. The work of microbes is the greatest instance we know of the economy of Nature—the law of her house. There are many lives which

seem useless—the humble life in the sea, for instance, and thousands of kinds of humble life in the earth under our feet. But even though all these lives seem to come to nothing in themselves, yet their work is never wasted. There is no wholly wasted life in the world, for there are always microbes ready to take the dead creature's body and prepare it, so as to be useful for future life, which may be better and higher life.

Our own lives—even the lives of the greatest men and women—are built upon these humble foundations, and so, in a sense, we may say that through the work of microbes even the humblest living creatures of the past live again in us. So in this wonderful way life goes on climbing, and perhaps even we, who think so well of ourselves, will some day be looked upon as only the stepping-stones to something higher still; and if microbes can help to that end, so can we.

MICROBES THAT HAVE BECOME A TROUBLE AND PLAGUE

Now, we must be quite fair, of course, in talking about microbes. Most people are very unfair, because they know nothing about all the useful and necessary work which microbes do, and talk about nothing but the harm which they do. But if that is unfair, so also would it be unfair if we should talk only about the good they do, and say nothing about the other side of the picture, for, unfortunately, there is another side.

All, or nearly all, the useful microbes we have been talking about live on dead matter; but, as we saw, there are a certain number of microbes who live, not on dead matter, but in and upon the bodies of creatures who are still alive. Probably all microbes began by living upon dead matter, but some of them learned how to attack the bodies of very old or nearly dying plants, or animals, and so at last produced the present race of microbes, which invade the living bodies of higher creatures, and are a terrible scourge to mankind.

Plants and animals and men may all suffer in this respect; but it is very interesting for us to learn that, when creatures live wild, as we say, in their natural state, in the open air of heaven, and in the light, they suffer little from microbes.

Wild animals and wild plants scarcely suffer at all. But when man takes various kinds of plants for his own purposes, and grows them in conditions which are not really natural, they are often attacked by microbes; and it is the same with animals. Oxen and cows suffer from consumption, for instance, but that is not when they are in their natural state, but when men take them and shut them up in badly ventilated and badly lighted places. We must learn to stop this, for the cows can give their consumption to us by passing on microbes in their milk.

Just the same is the case with the monkeys and many other animals that are kept in the zoos. In their natural state, these creatures are not attacked by microbes; but if we take monkeys, which ought to be living in the open air among the trees, and shut them up in covered cages, then the microbes of consumption attack them, and they die.

A LESSON THAT WE LEARN FROM THE MONKEYS

You would think that if you took a wild animal, such as a monkey, which naturally lives in a hot part of the world, and brought it to our colder land, the most important thing to do would be to keep it warm. However, they have learned at the zoos that the warmth does not matter very much, but that, if the animals are kept in the fresh air, even though it is colder than they are accustomed to, the microbes of consumption will not attack them.

This is a lesson for us, and we are just beginning to learn it. If monkeys and tigers and other animals were really meant to live in fresh air, with the sky as the roof over their heads, so also were men and women; and if we shut ourselves up, as we shut up cows and monkeys and tigers, microbes attack us, just as they attack them. The kinds of microbes which are useful to us, such as those that keep the earth sweet, those that help plants to grow, and so on, can thrive in the open air, and the light of day helps their work; but the dangerous microbes, and especially the microbe of consumption—which kills far more human beings every day than all the snakes and tigers in the world kill in a year—are themselves killed by open air and sunlight.

There are houses, perhaps, in every large city with rooms for people to live in where the windows are made so that they cannot open. There are thousands of rooms in many cities of the world which have no windows at all, and have to be lighted artificially all the day. No human being should live in such a room; microbes are almost certain to catch any one that does and kill him. It should be a crime to make such rooms.

A MOST TERRIBLE EVIL WHICH WE COULD STOP

The great truth is that in this case, as in so many others, men and women bring most of their evils

upon themselves. We talk about microbes as if they were our deadly enemies, and had somehow come into the world just in order to hurt us. This is nonsense. We could not live without them, and by far the greater number of them are unable to do us any injury. Those which hurt us most we bring upon ourselves.

We are especially thinking of the deadliest of them all—the microbe of tuberculosis, a disease from which many men and women have died since you began reading this part of our story. It is one of the most terrible evils in the world, but it is not necessary, and we could put an end to it in a few years if we all made up our minds that it must be done. If we lived natural lives, and if we allowed those of our fellows who are less fortunate than we are to live natural lives, the microbes of tuberculosis would not hurt us any more than they hurt other creatures which do live natural lives. But we do things that are unnatural. The laws of Nature teach us that we were made to breathe fresh air; we defy those laws, and then we cry out against Nature for her cruelty in sending the microbe of tuberculosis to kill us.

THE MICROBE THAT MAKES ALCOHOL

One of the most important of these microbes is not usually called a microbe, but it might quite well be so called, for it is a close relative of microbes and lives in the same way. There is no reason why it should be an enemy.

This is the yeast-plant, which turns sugar into alcohol and the gas called carbonic acid. We use it every day in making bread. The alcohol is blown away as a gas and the carbonic acid forms in the flour and makes the bread rise.

But we also use the yeast-plant to get the alcohol that it makes. This also is a very useful substance; it is used in hundreds of arts and industries; it is splendid for cleaning things and for preserving them; it burns beautifully and makes a splendid fuel; it is, perhaps, the cheapest and most easily made of all fuels for many purposes. It is far cheaper than petrol, which is now used for motor-cars, and most people expect that before long alcohol will be used to drive motor-cars, and also to work engines. So, if we had the sense to know how to use alcohol in useful ways, the tiny yeast-plant which produces it would be among the best friends of man.

But, as you know, men drink alcohol. Now, this substance is a poison to all living creatures, without exception, men or animals or plants. It is even a poison to the yeast-plant that makes it, and when the amount of alcohol in the sugar which the yeast-plant is feeding upon and changing reaches a not very high proportion, the yeast-plant is killed. So, if the process is wanted to go on, the alcohol has to be taken away as it is made.

HOW MICROBES WARN US TO TAKE CARE OF OURSELVES

By far the greater number of all human diseases are caused by the attack of microbes, the tiniest, humblest, and very nearly the oldest of all living things. Considering the murder they do every day, no wonder we are afraid of them; no wonder most of us think they are all evil. But the astonishing thing is that, while human beings almost always die of some disease—which is nearly always caused by microbes—yet animals do not die of disease except in comparatively rare cases. On the whole, we may say that microbes do not attack them, but only attack us. So soon, however, as we put animals or plants into conditions that are not natural, as we foolishly put ourselves, then they suffer just as we do and for the same reason.

Before very long we shall learn from this striking lesson that we cannot do without air and sunlight; that we must not be packed too closely together; and that, if we obey these laws of our own lives, then the lives of other living creatures, such as microbes, will scarcely injure us. If we can save the monkeys at the zoos from the microbes of consumption by keeping them in fresh air, we can also save each other in exactly the same way.

HOW ALCOHOL MAKES DISEASE IN EVERY LIVING THING

Alcohol is of no use to our bodies, but in time will cause disease in every part of them, especially the brain, which is the most important part of us. It also prevents us from protecting ourselves against other microbes. Most especially is it the great friend and ally of our great enemy, the microbe of tuberculosis, for which it prepares the way by making our bodies unable to resist it.

All over the world, wherever men are crowded together, this microbe destroys them; but now that we have found it out we shall probably make an end of tuberculosis, especially as we are beginning to attack its great friend, alcohol, made by the yeast-plant.

Probably the microbe of tuberculosis is one of those which can scarcely live at all except in the bodies of other living creatures, such as our-

selves, and so, when we prevent it from attacking us, it will no doubt die out altogether.

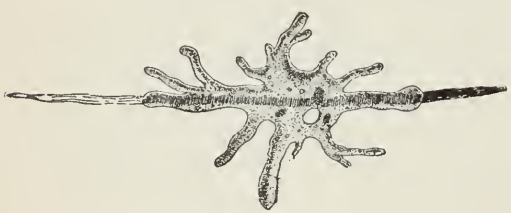
Of course there are many other microbes which hurt us, but we cannot say any more about them now; and though we have ended by talking about the bad side of microbes, we want you to remember that the trouble is largely our own fault, and that, though some microbes kill us, yet without microbes, as a whole, we could not live at all.

THE ROOT-FOOTED ANIMALS

MANY microscopic animals you can find—if you know where to look, and have some grown-up scientific friend to help you catch them—in small pools, ditches, and various damp places.

One of the many forms assumed by an amœba with its leg-like extensions. In this the appearance is decidedly root-like. The little animal can take small particles of food into any part of itself.

But, because you can find microscopic animals even in large numbers in some stagnant water, you must not believe that "all water is full of little animals," as we sometimes hear very incorrectly stated by people who do not know. The scientific man takes a drop of water in which some plants have decayed, and shows, by the aid of a powerful microscope, many interesting swimming and wriggling forms. He sometimes omits to explain that this is not ordinary drinking water; hence a wrong idea of microscopic life in water is often held by those who have not studied nature's wonderful homes.



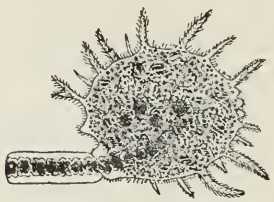
THE COMMON AMŒBA.

Eating a shred of water-weed by surrounding it. The leg-like projections (pseudopodia, or "false legs") can be extended from any part of the body.

Among the most wonderful of these tiny animals in water is the amœba, that looks when at rest like a tiny fleck of jelly. When the amœba starts to walk it can thrust out leg-like extensions from various portions of this jelly mass, and use those that point in the direction it wishes to go.

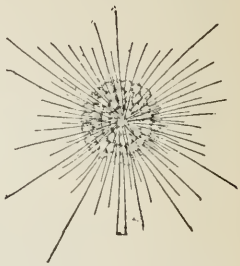
These extensions of the little amœba and of other members of the family have somewhat the appearance of the tiny roots of plants; hence the little animals are called "root-footed."

The little amœba can eat a plant much larger than itself, in a method somewhat similar to that of a starfish eating an oyster—by merely surrounding it.



AN AMŒBA SWALLOWING A DESMID.

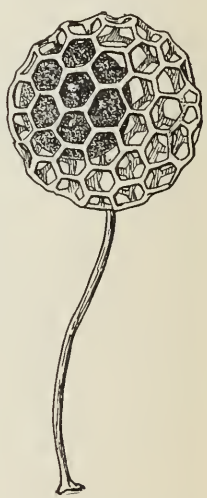
The desmid, a microscopic plant, is the stick-like extension at the lower left.



THE SUN-ANIMALCULE.

These rays are extended nearly all the time.

Scientists claim that the amœba never dies—except, of course, when destroyed by accident or eaten by some larger animal. When the amœba becomes above the ordinary size it extends itself out, somewhat in the shape of a dumb-bell. A little later the two globe-like ends are entirely separated, when each portion swims away as a complete little animal.

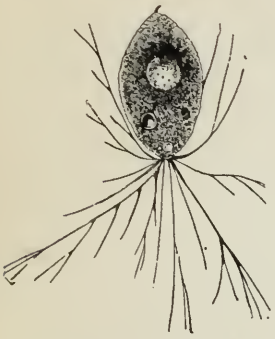


A RHIZOPOD (*CLATHRULINA ELEGANS*) THAT LIVES IN A MICROSCOPIC GLOBE OF LATTICE-LIKE GLASSY MATERIAL

But the amœba is only one of a large number of these strange "root-footed" animals. Many of the others live in the ocean, while still others live in fresh water, or even in damp places on land. In fact, they occur almost anywhere that is not too dry and where the water is clean. We can find them on the bark of trees, on the dripping rocks near waterfalls, in the ooze at the bottom of ponds and ditches, in the slime on submerged objects, on the under side of floating leaves, and in the water which we squeeze out of bog-moss. And many live in shells which, like the shell of clams and snails, are formed from the creature's own body, or are built up of sand grains and the hard parts of other minute animals and plants. Some of these little fellows are green, some are red or

brown, some are nearly black and some almost as clear as glass. They are often shaped like an egg, or a helmet, or an Indian pot, and have a single opening at the bottom of the shell. Through this opening the animal thrusts out its legs, and with them crawls along and seizes its food.

Instead of blunt, irregular "make-believe" feet, some have straight, slender rays two or three times as long as the body. One of these is the sun-animalcule, common among floating plants in standing water. It is so named because, with the round body and projecting rays, it looks for all the world like the picture of the sun in old prints. When some smaller creature touches one of these rays it seems to become paralyzed, and is drawn down the surface of the body to where a sort of lump rises up and swallows it. If the prey is too big for one ray to manage, half a dozen will surround it, becoming more or less fused together, while the lump which rises up to engulf the morsel is half as large as the animalcule itself.



AN INTERESTING FORM.

Pictured by Dr. Leidy, and called *Pamphagus mutabilis.*

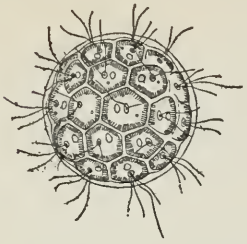
The sun-animalcule floats, and moves onward in a mysterious and unknown way, while some others, not very different in appearance, do not move about except when they are very young, but stand on long stalks and have a sort of lattice-work shell, the rays streaming out through the holes. As many as forty individuals of still another kind will tie themselves together by long bands, so that, being bright green, they look much more like some minute water-plant than like a colony of animals.

These are only a few of some hundreds of different kinds, many of which are likely to turn up unexpectedly almost anywhere. Indeed, one of the charms of studying these rhizopods (which is simply Greek for root-footers) is that one never can tell what queer thing he will find next.

EDWIN TENNEY BREWSTER.

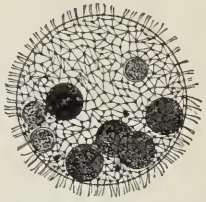
SMALL BUT INTERESTING FORMS OF LIFE

ONE day I found, in a damp place in the road, what looked like a dab of green paint. I was sure it could not be that, so I took some of it home for examination under the microscope. There I discovered that my find was composed of hundreds of minute polliwog-like things, each with a very slender lash-like thread at the front.



"MANY BODIES, EACH WITH TWO ANTERIOR LASHES."

(*Pandorina morun.*)



"STUCK ALL OVER WITH GREEN BODIES THAT LOOK LIKE DOTS."

(*Volvox globator.*)

They each had a soft, green body, and a red spot that seemed to be an eye. The tiny creatures, scores in a drop of water, swam about, with the whip-like lash foremost and wiggling so fast that it was almost invisible.

I had found a lot of euglenas, as they are called. You will find them described in the botanies as plants and in the zoölogies as animals, so you may take your choice and put them in either class. This is not very important, because among these lowly beings the difference between plants and animals is very slight indeed.

"LIKE A MISSHAPEN FLASK WITH A LONG NECK AND A MOUTH AT THE END WHERE THE CORK SHOULD GO."

(*Chetospira Mülleri.*)

One reason why we think that euglena is a plant is that many undoubted plants, at certain seasons of the year, break up into just such little tadpole-like bodies, which swim away and finally grow into new plants. Another reason is that there are two or three small water-plants —at least they are, on the whole, more like plants than animals— which are hardly different from a lot of euglenas growing together in a colony. One of these, pandorina, is made up of several bodies similar to euglena, even to the red eye-spot, but each with two anterior lashes. The bodies are bunched together in a spherical mass, with their numerous trembling threads sticking out in all directions. Sometimes the colony breaks up and the separate parts swim away to freedom. Sometimes each one of these parts splits up into sixteen smaller ones, which swim away and become full-sized colonies in their turn. Another of these water-plants is the volvox, a hollow sphere about the size of the periods on this page, and stuck all over the surface with

green bodies that look like dots. These are so numerous that when the whip-like lashes beat the water all together, they send the little green ball rolling and spinning along in a lively way.

"SUGGESTS A SWAN."
(*Trachelocerca olor.*)

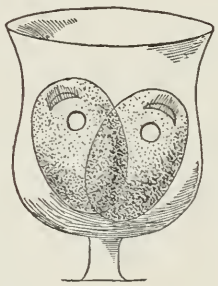
On the other hand, there are plenty of creatures which are usually counted as animals, but which, with the exception of their color, are nearly like euglena in structure. Some of these are red, some brown, some yellow. Seen under the microscope, they sparkle like little jewels, and where they occur, a thousand to a thimbleful of water, they color large patches of the ocean.

Besides these there are many microscopic creatures which are beyond all possible doubt animals and not plants, living almost anywhere in water, on the surface of the mud, or even in the bodies of larger animals. One sort is in form like a misshapen flask with a long neck and a mouth at the end where the cork should go. Another suggests a swan; a third an elephant. A fourth is like an anchor with horny flukes, while still another lives in a dwelling shaped like a goblet. In short, there is no end to their strange forms and wonderful structure.

"LIKE AN ANCHOR WITH HORNY FLUKES."
(*Ceratium tripos.*)

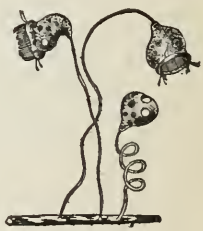
Some of the commonest kinds, however, are not less interesting. One has only to dip up a few gills of water from any pool or ditch, and let it stand in the window for a few days, to get hundreds of infusoria of several different kinds. The trumpet-animalcule (stentor) and the slipper-animalcule (paramecium) are particularly easy to find, and large enough to be seen, though with some difficulty, with the unaided eye. These move by means of countless little cilia, as they are called, instead of one or two long lashes, and they go whirling over and over as they swim, so that their course is straight ahead in spite of their lopsided bodies. They are so transparent that one can see much that goes on within them, and make out the balls of half-digested food and the smaller animals or plants which they have more recently swallowed. It is a lively sight when half a hundred slippers get together around a mass of bacteria, of which they are fond. They shove and push and butt one another for all the world like so many little pigs around the trough at dinner-time.

THE TRUMPET-ANIMALCULE.
(*Stentor polymorphus.*)



"LIVES IN A DWELLING SHAPED LIKE A GOBLET."
(*Cothurnia patula.*)

THE SLIPPER-ANIMALCULE.
(*Paramecium aurelia.*)



THE BELL-ANIMALCULE.
(*Vorticella nutans.*)

Another common infusorian, smaller than these and therefore harder to find, is the bell-animalcule (vorticella). When full-grown and in comfortable quarters, this is always fixed to some support by means of a long stalk. It has a tiny, roundish body, with a crown of cilia about the upper edge. When disturbed it vanishes like a flash; but if one looks closely, he finds it clinging to its support, its stalk coiled up like a spiral spring, ready to uncoil and let the creature blossom out again when the danger is past.

E. T. Brewster.

NATURE'S CURIOSITY SHOP

PART II

IV. EARTH AND SKY

WHAT IS LIGHT?

Men have long known that light is something which moves from place to place. It takes time for light to travel. The question, then, was to find out what was moving. Newton, one of the greatest men who ever lived, thought that light was a movement of tiny specks of something through space—as if a candle or a star were sending out a shower of tiny particles from itself in all directions. He thought that when these struck the eye they caused the feeling of light, just as a shower of raindrops on the hand causes the feeling of touch. This belief as to what light is was very long held. Men believed it, not so much because it was proved, as because Newton believed in it. Yet we now know that it is not true. There is a great lesson here. No greater mind than Newton's was ever turned to questions like these, yet even Newton could be wrong, and it was wrong to believe it on his authority alone. There is no authority but Nature itself, and everything that men say, however great they are, must be tested. We now know that light is a wave-motion in something which has never been seen and never will be, though it exists everywhere, and is called the ether.

HOW LONG IS LIGHT IN COMING FROM THE SUN?

Of course, any one who can do simple arithmetic can answer this if he knows at what rate light moves, and how far the sun is from the earth. The rate of the movement of light through the ether is well known, and it never changes. It is slightly more than 186,000 miles in every second. The sun's distance from the earth varies a little, because the earth does not move round the sun in a circle, but in an ellipse. But we may take the rough figure of 93,000,000 miles as the distance. Now, if we divide this figure by the other, we get an answer of about 490, which is the number of seconds it takes light to travel from the sun to the earth. The answer, then, which any one can easily remember, is: A little more than eight minutes. If we compare this with four and a half years, which about represents the time that light takes to reach us from the nearest star, it will help us to imagine what a wonderful distance the sun and his family are from their nearest neighbor.

WHENCE IS OUR LIGHT WHEN DARK CLOUDS HIDE THE SUN?

It depends on how dark the clouds are. If the moon passes directly between us and the sun, the earth becomes as dark as night because the moon is quite opaque, which means that no light can pass through it at all. But when it is only clouds that are between us and the sun, a good deal of light always gets through them, so long as they are real, clean water-clouds. Browning, the great English poet, says:

> "A sun will pierce
> The thickest cloud earth ever stretched."

But sometimes in great cities we make unnatural clouds ourselves, filled with smoke and dirt—mostly tiny specks of coal which we have sent up the chimney. These are the really dark clouds, full of solid black dirt, and there are times when they make the face of some cities darker than it ever is during a summer night. The coal was made by the sunlight of past ages, and we send it into the air to stop the sunlight that has traveled such a long way from the sun so quickly and surely to serve us. It has 93,000,000 miles to come, and just at the last half mile or so we stop it: is this not foolish? And we actually use past sunlight to stop it with!

DO WE SEE DISTANT THINGS OR LIGHT BOUNCING FROM THEM?

It is now possible to answer this extremely interesting question. What we see is the light that

has bounced from things or that has been made by them if they are luminous things, and we see it, of course, in our eyes; or, to be accurate, at the back of our heads, in the part of the brain where we really see. Yet we feel as if we see things where they really are. It is now proved that this is the result of practice and experience, and the knowledge which we have got by walking about and touching things.

A baby, when it begins to see and use its eyes, has no idea of distance. Its very first impressions, we can be sure, are of something in itself; then, as it discovers its own body, and uses its fingers, it learns that the things it sees are outside itself. Yet even then, for a long time, the baby will reach out its hand to things that are as far away as the moon. But we have better proof still. Persons born blind, who have received their sight when they were grown up, tell us that when first they see, they get the idea of something that is felt inside their heads. Only with practice do they learn to do what we learned to do when we were small—that is, refer to the outer world the sensations which, indeed, happen inside our heads.

WHY IS IT DARK AT NIGHT?

If you take a ball and hold it near a bright light, the half of the ball next to the light is shone upon, and the half of the ball away from the light is dark. If you mark a spot on the ball, and then turn the ball round and round like a top, that spot will be shone upon half the time and will be in the dark the other half of the time. We live on a big ball called the earth, which is always spinning round and round, and it is shone upon all the time, day and night, by a bright light called the sun.

The place where we live is like the spot on the ball, and as the great earth-ball spins, part of the time we are on the side next to the sun and part of the time we are on the side away from the sun. When we are on that side it is dark at night, but while it is our night it is daytime for the people who live on the other side of the ball. However dark it is where we live, the sun is always shining somewhere, and the earth is always traveling toward it or away from it. The sun does not come to the earth, but the earth comes into the sunlight. If you think of the ball and the light you will understand that, however dark it is, the earth will soon carry us round into the light again. Have you ever heard one of the most beautiful lines in all poetry: "There is a budding morrow in midnight?" It means that every night a day is being born.

HOW OLD IS MAN?

The pages of history have been pushed back many thousands of years in the last two decades, so that the answer which we would have given to this question a few years ago is very different from the one which we must give today, and we are by no means sure that the investigations of the future will not make a very different answer necessary in a few years more.

The most complete records of the life of man have been found in France and other parts of Europe, some of them proving that primitive man dwelt in France about 250,000 years ago. This takes us far back of the records of the civilizations of Mesopotamia and the valley of the Nile, before man knew how to build, or before he had organized himself into social groups.

This dim, far-away period is called the Stone Age, because man had no implements or tools except those made from the stones which he found about him, and even these he seems little able to have adapted to his use. He lived in caves with the materials for the building of palaces around him, and seems to have been but little above the wild creatures with whom he contended for these rough living places.

HOW FAR CAN THE VOICE CARRY?

The answer to this question seems very simple — we have only to shout to someone in an adjoining field and note that he does not so much as lift eyes in our direction to realize the limitations of the human voice.

But when we read that a man in Arlington, near Washington, talked to a man in the Eiffel Tower, in Paris, in 1916, and that a man in Honolulu listened to the conversation, we suddenly realize that the answer is not so simple after all.

Moreover, this conversation was carried on without telephone wires, the medium of transmission being only the waves of the air, known as the Hertzian waves, which had already been so wonderfully utilized in wireless telegraphy. This new method of communication is called wireless telephony, and by it the very inflections of the voice were carried one third of the way around the world and back again, crossing the Atlantic and a part of the Pacific oceans.

The United States Navy has been a leader in the work of conquering the waves of the air, and with high-power stations at Arlington, San Diego, Honolulu, Guam, Manila, and other points is proving that Puck's promise "to put a girdle around the earth in forty seconds" was not so impossible after all.

A MARCH FANTASY

DRAWN BY I. TABER

By means of wireless telephony the human voice can travel around the earth seven times in a second. Of course one must have the right kind of a receiver to catch the sound waves, which spread forth in all directions instead of running along a wire. Someone has said that "eavesdroppers have certainly come into their own, when Honolulu can 'listen in' while Washington talks to Paris!"

Wireless telephony may be said to be a miracle of the twentieth century, though we have seen so many miracles wrought in the last two decades that we will by no means commit ourselves to the statement that nothing more wonderful than this is possible.

WHAT IS FLOOD-LIGHTING?

The old plan of lighting was to make the illuminated object a source of light — to cover it with lanterns, lamps, or to put great searchlights upon it. This had the effect of making the surroundings light, and often but intensified the shadows of the object which they were supposed to illuminate.

Flood-lighting surrounds the object with lights, these being so placed that they shine directly upon, rather than from, the object. This is the method now used to light the dome of the capitol at Washington, which stands out in the darkness a marvelous building of light. The great dome is 135 feet in diameter at the base, and rises 213 feet above the roof of the building. Eighty-four projectors, each equipped with 400-watt lamps, were placed in four "banks" located about 200 feet from the dome, on the corners of the Senate and House of Representatives' wings of the building.

The capitol building is also lighted, though with fewer lights, to make it a setting for the brilliantly lighted dome. The building is about 750 feet long and 250 feet wide. The main building is of sandstone, painted white, and the House and Senate wings at the ends are of white marble. Surrounding the building on three sides is a wide concourse bounded by a parapet. Thirty-four flood-lighting projectors each equipped with a 400-watt flood-lighting lamp, were mounted on the ornamental posts that are placed on this parapet.

The Statue of Liberty, in New York Harbor, is also lighted by flood-lighting, and welcomes the traveler by night as well as by day with its message of "Liberty Enlightening the World," a message which the world is just beginning to understand.

WHY WILL LIGHTNING STRIKE SOME THINGS AND NOT OTHERS?

We know that if lightning can choose between a lightning-rod—that is to say, a rod of iron—and the rest of the roof of a house, it will go down the rod. We know that it will always choose metallic things rather than any others. And it will strike a tree rather than the ground beside the tree. In every case the principle is the same. It is that electricity will always choose the easiest path. The usual way of saying this is that it takes the path of least resistance, and the principle is true of many things besides electricity. It is often true of ourselves. Thus, if the electric current can pass to the earth through a tree, it will do so, because the tree helps its passage downward. That is why we should never stand under a tree during a thunder-storm. But, for choice, it will always pass through anything made of metal, such as iron, for the whole group of metals are good conductors of electricity—the best there are. We do not know why they conduct it so well, but we do know that that is the reason why lightning chooses to pass through them. So a lightning-rod will protect a house, provided that it runs right down into the earth. If the lower part of the rod has rusted away before it reaches the earth, as sometimes happens, the electricity will be discharged into the house, and then the rod does more harm than good, for it attracts the lightning to the house, and does not protect it.

WHY DOES THE MOON GROW BRIGHTER AS THE SUN SETS?

If we watch the moon as the sun begins to set, we shall see it grow brighter and brighter, until, when the night has come, it is quite bright. Of course, it has really been shining just the same all the time, but the sun is sending so much light to our eyes, both directly and reflected from the air, that the light of the moon seems pale, and not worth calling even moonshine.

It is the same with all our opinions and feelings. One person in a room may shine so brightly by his talk that other people do not seem to shine at all; but when he goes we notice that they are shining too. And, if we have a headache and suddenly knock our shin hard against something, we shall not feel the headache until the stronger pain in our shin has passed away. The sun puts out the moon just as it puts out the fire; it does not really do so, but it seems to our eyes to do so.

The moon and the stars shine by day, though we cannot often see them. And the sun shines

by night, only we cannot see it. We are unable to see the sun shining at night, because we are on the opposite side of the earth to it.

WHAT MAKES THE RAINBOW—WHERE DOES IT END?

The rainbow is made by drops of rain; it is due to the reflection of sunlight from drops of water hanging in the sky. As the sunlight passes through the raindrop, and is reflected from the inside of the back of the raindrop, it is broken up into its various parts, which correspond to the various colors of the rainbow.

White light, we know, is a mixture of many colors. The light-waves corresponding to these colors differ in the extent to which they are bent by passing through such a thing as a raindrop, and so, when they come out of it, they are sorted out, so to speak; and what was white light on going in, comes out as a band of several colors. Thus, what we see in the rainbow is really a natural spectrum of sunlight—the light spread out in a band of the various colors that make it up.

As we trace the rainbow down on each side it seems to touch the earth, and there are stories of children who have set out to find the end of the rainbow. But the rainbow ends nowhere, for it is a mere appearance in the sky, due to tiny drops of water, and it "ends," if we are to use that word, simply where the drops of water end that are so placed as to reflect the sunlight in this way to our eyes. Really no two persons see exactly the same rainbow. They could not do so, unless their eyes were in the same place. And as we move, the bow we see moves with us.

WHY DO WE SEE THE GUN-FLASH BEFORE WE HEAR THE NOISE?

When the gun goes off it produces at the same moment light, which makes the flash, and sound, which makes the report. Light is a wave in something which is everywhere—the ether; and sound is a wave in air.

Like all waves, in water, or air, or ether, these waves take time to travel. But sound-waves travel very slowly compared with light-waves. Sound moves only some hundreds of feet in a second, while light will go more than 180,000 miles in a second! If you are very near the gun you will hear the report and see the flash so nearly together that you cannot say which was first; but the farther you are from the gun the greater will be the difference of time, because the light reaches you so quickly, while sound comes lagging after it. You will see the flash always within a tiny fraction of a second after it happened, but the sound-wave may take a second or two to reach you if you are far away.

Just in the same way, if you watch a game of base-ball from a distance, you will see the bat hit the ball, and then, afterward, you will hear the bat hit the ball.

WHY DO THINGS FADE IF THE SUN SHINES ON THEM?

When such a thing as a curtain, a carpet, or a piece of cloth fades, it is because the chemical substances in it that give it its color have been partly destroyed. Most of this coloring-matter consists of substances which can be burned, or oxidized, and if a thing is exposed to the air, of course there is plenty of oxygen round about it. The sun's rays destroy the color, because they help on this chemical change that we call oxidation. Every photograph is taken because of the power of the sun's rays to produce chemical changes, and the fading of a piece of cloth exposed to the sun is really very much the same as what happens in a photographic plate. The part of the sun's rays which has this chemical power is the part which produces the colors of blue and violet when it strikes our eyes, and also two or three color-notes, as we might call them, higher up than the violet, which our eyes cannot see, and which are called ultra-violet.

The sun, then, has in itself the power of altering the dyes in a carpet or a curtain, and if it alters them enough the color of the thing changes. But there are dyes which are fast, as we call them. This simply means that the sun does not do anything to them, and the beautiful dyes which plants use to color their flowers are all fast dyes; at any rate, they do not fade while the flower is alive.

WHY DOES THE SUN MAKE OUR HANDS AND FACES BROWN?

For a long time the answer to this question was very uncertain. Doctors used to have the idea that every change produced in the body out of the ordinary was a disease—was something wrong. But a great many of these things that are too often looked upon as diseases, or as something wrong, are really instances of the marvelous power of the body to adapt itself to special circumstances. In this case, for instance, it used to be thought that some injury was done by the browning of the skin.

What really happens is that the skin turns

brown in order to protect the blood underneath it from the too strong rays of the sun. The brown paint, or pigment, as it is called, that is formed in the skin catches up the sun's rays and absorbs them, and so the precious blood that runs in thin-walled blood-vessels just under the skin is protected.

Sunlight is exceedingly good and necessary for us, but there is only a certain intensity of it that is good, and beyond that it becomes harmful. People vary much in the extent to which they brown under the sun. It is said that the people who can live best in the tropics are those in whom the skin has the best power of making the brown pigment to protect the body. It may be that the deep color of dark races is protective, and that is why we find darker peoples nearer the tropics and fairer peoples nearer the poles.

WHY IS IT WARM IN SUMMER?

We might think at first that perhaps the earth is nearer to the sun in summer than in winter, and so the air is warmer and the sun's rays hotter. We know that the earth does not move in a circle round the sun, but in a sort of oval path called an ellipse. But the fact is that, though the earth is nearer to the sun during part of the year than it is during the rest of the year, it is nearest in winter and farthest in summer, in the northern hemisphere. The difference in distance is so small that it does not affect the weather much; but no doubt if the earth were nearer the sun in summer and farther off in winter, summer would be a little hotter and winter a little colder than it is.

That our distance from the sun does not make the seasons is plain when we remember that in our winter it is summer in Australia. It is warm in summer because then the sun's rays strike the earth more directly; the sun rises higher in the sky, as we say, and that means the same thing. The air is like a great blanket; it keeps heat in and it keeps heat out. If the sun's rays strike straight downward to the earth through the air, they do not have to travel through so much of it as if they traveled through the air slantwise.

WHAT IS THE FORCE IN LIGHTNING THAT KILLS QUICKLY?

We use the word lightning to mean two distinct things—first, the light that is seen when electricity passes strongly from a cloud to the earth; and, secondly, the electricity which causes that light. The light itself is quite harmless. It may be seen at a great distance from the place where the lightning really passed, but whether it is seen from afar, or close at hand in a blinding flash, it cannot hurt any one.

But the electricity itself is very different. If this strikes the ground close beside a man, it will do him no harm; but, if it actually passes to the earth through his body, it may kill him. It does this very suddenly, as a rule, by affecting the brain and the nerves that run from it to the heart. As we know, two of these nerves, one on each side of the body, are capable of stopping the heart altogether, if they act powerfully. The electricity, in passing, stimulates, or excites, those nerves, so that they stop the heart, and the person dies from shock.

WHAT MAKES THE SUN ALWAYS HOT?

"Always" is too big a word to use of the sun's heat, even though the sun has always been hot ever since there have been men to look at it, and long before. The sun will not be always hot, nor has it been always hot. Long ages ago, before the earth and the sun were anything like what they are now, there was not nearly so much heat. The heat was gradually formed, it seems, as the great mass of cloud or nebula from which earth and sun were made shrank.

The central part of this cloud, then, the part which we now call the sun, has had a wonderful history, and we can see stars in various parts of the sky which show different stages of what has been the sun's history. It is almost certain that the sun was once much hotter than it is now; probably white-hot, like the whitest of the stars.

It is now yellow-hot; it will some day be red-hot, and then gradually become dull and dark until the light goes out of it altogether. But this will be so many ages away that we cannot possibly imagine the length of them.

WILL THE SUN EVER COOL DOWN LIKE THE EARTH?

There can be no doubt that the answer to this question is yes. The sun, the earth, and the moon are all made of the same stuff, and they are all cooling down according to the same laws. The moon, no doubt, is much the coldest of these three, but that is because it is the smallest, and small things cool down much more quickly than large things, because small things, in proportion to the stuff that is in them, have such a large surface to lose their heat by. The earth is bigger than the moon, and therefore not yet so cold. The great planet Jupiter is very much bigger than the earth, and is still so hot that it probably

THE MEADOW-GRASS AERO CLUB'S FIRST OUTING

makes a little light of its own besides what it reflects from the sun. The sun is very much bigger even than Jupiter, and so has not cooled down anything like so much. But if we study the sun, and compare it with other stars, we can be sure that the sun is cooling, and one day it must become cold.

WHY IS INDIA HOTTER THAN OUR OWN COUNTRY?

We live "between two fires," as the saying goes. Underneath us is the fire of the earth; above us, as we say, is the great fire of the sun. Now, the differences between different parts of the surface of the earth, which make India, for instance, hotter than North America, have nothing to do with the fire that is underneath us. The whole difference is due to the way in which the heat of the sun strikes the earth here as compared with India.

The sun's light and heat have to pass through the air before they reach us, and the air takes up a great deal of both light and heat as they pass through it. In parts of the earth, then, where the sun's rays pass straight through the air, it is very hot and the sun is very bright.

In such parts of the world the sun seems to rise right up into the top of the sky, and the people are protected only by just the bare thickness of the air. But in other parts of the world the sun's rays have to pass through the air in a slanting direction, so that they really have a very much longer journey through the air than if they came straight down through it; and so the sun seems much less bright, and its heat is far less intense.

WHICH TRAVELS QUICKER, HEAT OR COLD?

One of the wisest men who ever lived, Francis Bacon, said that the business of knowledge is often not so much to answer questions as to know what questions to ask and how to ask them. The great business for us, he said, is "rightly to put the question to Nature." This deserves a place among the wisest things that have ever been said. It is just when we learn how to ask a question that we gain more knowledge, and that is equally true, whether we can answer the question or not. Often men have learned great things simply because some one has said, "You cannot ask that," of a question which men have been asking for hundreds of years.

Now, this question is one which we "cannot" ask, for there is no such thing as cold. Complete cold, if we could get it, would only be complete absence of heat; and what we ordinarily call cold is simply less heat than in something else with which we are comparing it. When a thing gets cold, it really gets less hot. So we cannot speak of cold traveling, unless we mean that it is a cold wind that is traveling, or cold water traveling through hot water, as when you run cold water into a hot bath. But we can say how fast heat travels, if by that we mean the rays of heat or radiant heat that we feel near a fire or a light. This kind of heat is really the same as light, and it travels at exactly the same speed, which you know. But cold travels at no speed, for there is no such thing.

WHAT MAKES HEAT TRAVEL ALONG AN IRON BAR?

There are many ways in which heat travels from one place to another. One way is by rays, and is called radiation. Then again, heat can move about simply because a hot thing moves about and takes its heat with it. That happens in a kettle when it is boiled. The hot water at the bottom runs up to the top, and takes its heat with it. This is a case of carrying the heat, is it not? And so, when heat moves in this way, the proper name for it is convection. If you think that a very difficult word, all we can say is that it is just the same as the word "conveying," and if you know what to "convey" means, you know exactly this way in which heat travels.

Now, you will say this is all very well, but when heat runs along an iron bar it is not a case of radiation, nor is it a case of conveying or convection, for certainly parts of the bar do not run through it carrying the heat with them. And you are quite right. If you read the next answer, you will find what you want.

WHY DOES NOT HEAT RUN ALONG A STICK?

A poker is an iron bar, and we know that heat runs along it; yet a stick of firewood, though it is very short, may be burning at one end, and you can hold the other end in your hand without finding it hot at all. The heat does not run along the stick.

Now, in the case of the poker, the heat travels along through the little parts that make the poker, not because they move, but because each of them hands it on to the next. The proper word for this is conduction, and you see that it is quite different from convection or conveying. It is as if the atoms of the poker were a sort of stepping-

stones, and the heat walked from one to the other. Now, the poker is so made that the atoms of it are good stepping-stones for heat; indeed, iron, like all metals, lets heat run through it very quickly.

The proper way of saying this is that all metals are good conductors of heat. But wood is made differently. It is as if the stepping-stones were too far apart, so that the heat cannot pass across them. So we say that wood is a bad conductor of heat. Everything that is good for making clothes is a bad conductor of heat, but we think you knew that already.

WHY DOES CELLULOID CATCH FIRE SO EASILY?

Paper catches fire easily because it is made from vegetable substances which contain large quantities of carbon and hydrogen, and not very much oxygen. So, when it is made hot by a match or some such means, the carbon and hydrogen of the paper combine with the oxygen of the air, and the paper burns.

Now, celluloid is made from paper by the use of strong acids that turn the paper into a new compound which has very convenient properties. When hot it softens, and can then be molded into various forms, which it retains when cooled. Celluloid has very much the same composition as paper, though it differs in some respects, and it burns for the same reason that paper does.

The material that makes the hard part of plants, and from which paper is made, is called cellulose, and it belongs to the same class of substances as starch and sugar. A certain quantity of celluloid is practically cellulose combined with a proportion of nitric acid.

WHY IS IT COLD IN WINTER?

In winter the sun's rays have to pass very slantwise through the air, and so lose a great deal of their power. The reason of the difference between summer and winter—indeed, the cause of all the seasons—is that the earth is tilted on its axis, the line running through it from the north pole to the south pole. The globes, made to represent the earth, which help us to learn geography are always tilted. Imagine the sun as a strong lamp on the floor, and the earth as a spinning top on the floor, going round the sun. If the top is spinning upright, then at every part of its path round the lamp it will be in the same relation to the sun. But if the top spins tilted, as the earth does, then part of the time the upper half of it will be tilted toward the sun and the lower half away from the sun; and on the other side of its path the upper half will be tilted away from and the lower half tilted toward the sun. We whose homes are in northern lands, live on the upper half of the great top called the earth, and in our summer this half is tilted toward the sun, and in our winter is tilted away from it. So our summer is the Australian winter, and the Australian winter is our summer. The tilt makes all the difference to the sun's rays as they pass through the atmosphere. It might have been that the earth was not tilted in its path round the sun, and then we should have had no seasons.

WHY ARE SOME THINGS COLDER THAN OTHERS?

In an ordinary room without a fire all the different things are just as warm as each other, because, if it has time enough, the warmth will spread itself equally over everything about it, running from anything that started hotter to anything that started cooler.

Yet if you go and touch several of the things in the room, one after the other, you find that they feel very different as you touch them. A thing like the fender will feel cold; the carpet will feel warm; wood will feel colder than the carpet, but warmer than the fender. Now, that is simply because these things differ in their power of keeping heat from running through them, just as flannel and linen differ. The brass of the fender lets heat run through it very quickly, but the carpet lets heat run through it very slowly, and so we say that the fender feels cold and the carpet feels warm, just as a linen sheet feels chilly when we get into bed, while a woolen blanket feels warm. If a thing carries heat quickly away from our finger, it makes our finger cold, and we say that the thing is cold; and we call another thing warm in comparison with it, if that other thing, like flannel, only carries away the heat from our finger very slowly.

WHY DOES WATER FREEZE?

This sounds quite a simple question, but, indeed, no one can answer it yet. We do not know why taking heat out of water should at last turn it from the liquid into the solid state. It is believed, however, that we are wrong in supposing that there is a perfectly sharp line between the liquid and the solid state of water or of anything else. It is probable that water turns into ice or ice into water through unbroken stages. Only in most cases, and certainly in that of water, these happen so quickly that we have not time to notice

them. In other cases, as in that of sealing-wax, no one can say where the solid state ends and the liquid state begins.

If we are ever to learn why water freezes, we must certainly discover all we can about the nature of ice, and it is not difficult to find, in the first place, that all ice is made up of crystals. So we must understand crystals, and the reason why so many kinds of matter, when solid, form themselves into crystals.

This is a most difficult subject to study, but the laws of crystals are being very slowly worked out, and when that is done, perhaps we shall be able to say why it is that water freezes when it is cooled, although we cannot do so now.

WHY DOES ICE TURN INTO A LIQUID WHEN IT IS HEATED?

This question is, perhaps, really the same as the last, yet, in a way, it is easier for us to understand why ice turns liquid when heated than why water turns solid when cooled. We have a good working idea of what heat is. We look on it as a movement in the atoms and molecules of which matter is composed. Cold, we know, is simply the absence of heat. So we can understand why solids, especially a crystalline solid like ice, turn liquid when heated, because we can imagine the particles of them beginning to move to and fro so rapidly that they can no longer hold together in the regular way required to make the crystals of a solid substance.

WHY DO SO MANY PIPES BURST DURING FROSTY WEATHER?

We know already that water has a great peculiarity in the way it behaves when it is cooled. The rule is, that a thing contracts and shrinks as it cools, and if water is cooled down to within a few degrees of its freezing-point, it obeys this rule. But if it is cooled still farther, it then begins to expand, until it freezes and turns into ice. So ice occupies more space than the liquid water which is nearly cold enough to turn into ice, but not quite. When the frost comes, it often freezes the water in the pipes in our houses, and, as this means that the water, in the form of ice, occupies more space than it did before it was frozen, it cracks the pipes.

The water, when it freezes, is stretched, so to speak, to form ice, and bursts the pipe that tries to prevent it from stretching or expanding itself. This gives us some idea of the power of its expansion. Of course, as long as the frost continues, we do not notice any bursting of our water-pipes, but, as soon as the thaw comes, the ice in the pipes melts, the water runs out, and causes damage. Many people therefore think that the thaw bursts the pipes, but, as we see, they are wrong. The frost bursts the pipes, and the thaw only shows us that they are burst.

WHERE DOES THE RAIN GO?

Many things happen to the rain that sinks in the earth, and exactly what happens depends largely on what the surface of the earth is like at that particular place. A great deal of the rain remains in the soil to the depth of some feet, as soil water or ground water. If there is no such water there can be no vegetable life. But in places where rain falls, and the ground holds some of it, there we are sure to find plants of various kinds, that suck up a good deal of this water into themselves by their roots, and then give it back to the air. The soil also contains all sorts of life of other kinds besides green plants, such as various kinds of animals, like worms and insects, and also countless numbers of microbes. All these take up and use for their lives some of the water that the rain gives to the soil.

But still a great deal of the rain is not used up in any of these ways. Much of it is sucked up again into the air by the sun's heat, when the rain stops falling. Much of it also goes on sinking slowly through the earth until it reaches a layer of something that it cannot sink through. It may be carried on this layer to some lower level, where it may bubble up out of the ground as what we call a spring. In the long run almost all the rain that is not kept by living things, or given back to the air at once, gets into streams and rivers, and into the sea, where the sun sucks it up to go on its round again.

WHY IS IT THAT THE SEA NEVER GETS ANY LARGER?

This is a question about which men have always wondered. Thoughtful children and grown-up people will be asking these questions again in a thousand years. Let us tell you how it was asked and answered by the Hebrew preacher long years ago (Ecclesiastes 1. 7): "All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again." So we see that this question is answered in the Bible. What happens is that the power of the sun sucks up some of the water from the sea, and then it is poured back upon the land in the form of rain, and that makes the rivers. Besides this, in many parts of the world the sea does get

larger, because it wears away the land; but in other parts of the world the land extends and the sea gets smaller.

HOW DEEP IS THE DEEPEST PART OF THE SEA?

The Pacific Ocean is now believed to be deeper, on the whole, than any other sea, and the average depth of the greater part of it is said to be about 2500 fathoms. A fathom is six feet, so we can easily calculate this for ourselves in yards or miles, as we please.

But far greater depths than this have been recorded within recent years, not to mention cases where bottom has not been touched even at very great depths. It is probable, and easy to remember, that the very greatest depths of the sea about correspond to the greatest heights of the mountains on land, and we may put down such distances as five or six miles as roughly representing what we may believe to be the very greatest depths of the sea.

The very interesting question we must ask is: How near do such depths go toward piercing right through the earth's crust? The answer is that these abysses can represent only places where the earth's crust is, say, one-eighth less thick than it is elsewhere.

HOW DO MEN FIND OUT THE DEPTH OF THE SEA?

The simplest plan is by letting down a weighted vessel by a rope, marked off at intervals, and when it is felt that the vessel has touched the bottom, pulling it up again to see what has got into it.

But this will do only for very shallow depths, comparatively. When it comes to sounding great depths, we must first abandon the rope and use a wire, as was first done by Lord Kelvin. The wire rubs against the water far less than the rope, and when we are dealing with lengths of miles, that is an important matter. Also, when great depths are being sounded, it is hopeless to expect to drag up the weight that has sunk the wire.

So devices are used that will let the weight go at the bottom, and perhaps some tiny, light vessel can be left at the end of the wire, not too heavy to pull up, which will carry some evidence of the life that exists at the bottom. Sea-sounding is a study that has been greatly improved lately, and it has taught us very much about the strange powers of life under hard conditions.

HOW CAN WE TELL WHAT IS AT THE BOTTOM OF THE SEA?

We do not yet know all about the bottom of the sea, but there are several ways in which we can learn something of it. We can comfortably study a great deal of what was once at the bottom of the sea, when the sea has gone somewhere else, and has left it high and dry. For instance, we can study chalk-cliffs, and learn from them a great deal about what the bottom of the sea is like, or has been like.

Then we can send divers down to the bottom of the sea where it is not very deep, and they can look through the glass plates in their diving-helmets, and can see the plants and animals of many kinds that live at the bottom of the sea. They can bring some of these up, and at zoölogical gardens we can see for ourselves, at close quarters, many of the wonderful creatures that live at the bottom of the blue sea, such as sea-anemones.

But divers cannot go down many scores of feet, and the sea is often miles deep, as we have seen. If we want to learn about the deeper parts of the sea, we must dredge them—that is, let down something that will scrape along the bottom and catch hold of anything that will come away; and then the catch can be hauled up to the surface, and we can study it. This is costly, and takes time, but much of it has been done, and we have already learned a great deal about the bottom of the sea by this means.

Three, five, or eight miles below the level of the sea there cannot be very much light, and though it cannot be perfectly dark, yet it is what any of us would call quite dark. Here live a strange medley of creatures—strange fishes and seaweeds. Down to them, from above, there descend the remains of all sorts of other sea-creatures that live in the heights of water above them.

If we remember that the sea covers something like five-sevenths of the whole earth, we shall see that, of the total amount of life upon the earth, a very large proportion is to be found at the bottom of the sea. It is life of a very humble kind for at least two reasons. One is the immense pressure of the water above it, which prevents the development of more noble forms of life; the other reason, that has the same result, is the very small quantity of oxygen that is available for the purpose of life at the bottom of the sea. This means, of course, that the life of these creatures must be lived very slowly, and is indeed very different from the life of creatures that have air to breathe or even of a fish that lives in a stream

which has plenty of oxygen dissolved in the water all around it.

HOW DOES THE MOON CAUSE THE TIDES?

Let us suppose for a moment that the moon did not go round the earth, but simply moved through space with it. Then the moon would appear to rise and set, as it does now, only it would rise and set at the same time every day. And so, at the same time every day, in any part of the world, there would be tides, as there are now. The only difference between this and what actually happens is that the moon is moving round the earth, while the earth turns upon herself. This makes the moon seem to rise and set, in any place, about half an hour or so later every day; and the tides, we find, always correspond.

The moon is made of matter, and so is the water of the sea. All matter everywhere pulls, and is pulled toward, all other matter everywhere. We call this gravitation. So far as the whole earth is solid, the whole earth, and the whole moon, are affected by this pull; but as part of the earth is ocean, so to speak, and as water is not rigid, it can be, and is, specially affected by gravitation. The water opposite the moon at any time is pulled up toward the moon; and as the earth is turning all the time, this really means that a mighty heaped wave of water travels over all the oceans, day and night, in response to the pull of the moon. If the moon had oceans, there would be tides there too, owing to the earth's pull; and as the earth is very much bigger than the moon, these tides would be enormous. But the moon has no oceans, though possibly it has ocean-beds, long since dried up. All the moon does is simply to pull the water toward it as the earth twists and exposes new parts of water to its action.

WHY ARE THERE TWO TIDES A DAY?

This is a very puzzling question, to which very few people know the answer. The earth spins round only once in a day, and the moon pulls the water up toward itself on the side of the earth next the moon, making what we call high tide. Any one would think, then, that there must be only one high tide a day. But the moon not only pulls up and heaps up toward itself the water on the side of the earth that is next it at any given moment; it also pulls the earth toward itself away from the water on the other side of the earth, the side farthest from the moon.

The moon attracts the earth more powerfully than the water on the far side of the earth, since that water is farther away from the moon. So when it is high tide anywhere, it is also high tide on the other side of the earth. This must mean that we get two high tides in twenty-four hours.

The first of them, perhaps, is due to the moon heaping up the water on the side of the earth next it—the side of the earth where we are. But twelve hours later the earth has spun round so that we are on the side away from the moon, and now the moon is pulling the earth toward itself more strongly than it is pulling the water, so the water where we are is heaped up again, and that, of course, makes the second high tide we have in the twenty-four hours.

WHAT MAKES A CURRENT IN THE SEA?

You probably know quite well what a current is; it is not the same thing as a wave, which, though it seems to move onward, is really due to the water moving up and down. After the wave has passed, the water is in the same place as it was before. But in the case of a current—which really means something that is running—the water is actually moving from one place to another. There is a lake in Switzerland through which a river runs, and by the difference in the color of the water you can see where the river is. That is a real current. In that case it is easy to understand what makes it. The water of the river is falling to the sea, which is lower down than the place where the river started, and it is really the earth's attraction which is pulling the water of the river through the lake, so making the current.

In the sea also currents are due to something which is pulling or pushing part of the water of the sea through the rest of the water. We are sure you see that this is quite a different thing from a wave traveling over the sea, in which case the wave travels, but the water really does not. These currents may be due to many causes; sometimes it may be a steady wind blowing for some time in one particular direction, and not only making waves, but also driving some of the water of the sea really before it. More often, perhaps, currents are due to differences in the heat of the water. Warmer water in colder water will keep to itself, so to speak, and will move through the sea. If the sun shines brightly on a particular part of the sea, then it makes the water there hotter, and so may start a current. Indeed, the currents of water in the sea are often due to very much the same causes as the currents in the air, which we call wind.

"BRUCE AND THE SPIDER."

PAINTED BY B. COBBE.

"YOU DO LOOK FUNNY."

PAINTED BY T. R. KENNEDY.

V. EARTH AND SKY

WHAT KEEPS THE EARTH FLOATING IN SPACE?

The answer to this question is that the earth is not really floating in space, but is moving. There is nothing floating in space. The sun and the moon and the planets are moving, we know. Men used to think that the stars were fixed, and they called them fixed stars in order to contrast them with the planets, or wanderers. But the fixed stars are moving too; there is nothing at rest anywhere; nothing is floating in space, but everything is shooting through it. We do not know how these movements started, and we do not know how they will end, though we are just beginning to see order in them.

The real idea that we should have of the earth in space is not of a ball that is floating, but of something which is rushing round the sun, and which, if it stopped doing so, would in a few moments rush into the sun and disappear forever; and also that the sun and the earth, and all the rest of the sun's family, are rushing through space at the rate of several miles in every second, no one knows whence, and no one knows whither.

WHY CANNOT WE FEEL THE EARTH GOING ROUND?

The answer to this is that we are going round with the earth, and, as we are moved round with it at exactly the same rate and in exactly the same direction, we notice nothing. If you were in a train and did not look out, and the train moved at a constant speed in a straight line, and gave no jolts at all, you would not know it was moving; but, if it suddenly went more quickly or slowly, you would feel its motion. So, if the earth were suddenly to go round very quickly—say, so as to make a day of six hours instead of twenty-four—we might feel that it was going round because our bodies might be affected, as they are when a train suddenly gives a jolt as you get in, and you find yourself in some one's lap.

The real lesson that we can learn from this question is that the only kind of movement which we can feel is relative movement—that is to say, movement of one thing as compared with another. If the earth or a train moved more slowly or more quickly than our bodies, then we should feel the movement. If we could imagine our body moving alone in space with no stars for mile-posts, then we should not know it was moving, for there would be nothing to go by—nothing to compare it with. We can feel relative motion just because there is something to compare it with. That is how we know the sun and earth are moving—by comparing them with other heavenly bodies.

WHY DO EARTHQUAKES SHAKE BUT PART OF THE EARTH?

People who study these things have just been telling us that we really need two words for what happens in what we call earthquakes, and this question suggests exactly the point they make. We should really speak of *earth-quakes,* and of *earth-shakes.* In an earth-shake, the whole earth is shaken as it rolls through space, and this must happen because the earth is a ball, and we cannot shake part of a ball without shaking the whole of it.

But if the ball is a very big one, as the earth is, and if it is made of a great many different parts, including a crust of many layers, it is quite possible that we might have a disturbance somewhere that would shake one of these layers against another, without shaking the ball as a whole; and that is the kind of disturbance that we should call an earth-quake, and not an earth-shake.

"WHAT MADE THE MOUNTAINS?"

We think we ought to say what made and what *makes* the mountains. This question is a very important and good one, but the way in which it is usually asked suggests the greatest of all errors about the history of the earth. When we say "What made the mountains?" it sounds as if they had been made in a day, once for all, and that was the end of it. Mountains are being made and unmade to-day as they have been for ages past, and as they will be for ages to come. The forces that made and make them are the shrinking, and therefore wrinkling, of the earth's crust as it settles down upon the contracting interior.

If we look at the folds on the skin of a shrunken apple, we are undoubtedly learning something about the way in which mountains are made. But that is not nearly the whole answer. It may be that, to a greater extent than we have ever thought before, mountains are piled up and forced up from below in a way which is perhaps not so very different from the making of volcanoes. We can only say again at this stage that we are just beginning to guess what is the work done by radium in the rocks that make the earth's crust. We shall probably be certain before long that radium is one of the makers of mountains.

HOW ARE VOLCANOES FORMED?

This is one of those questions about which men are learning new things almost every month. We can be quite certain that volcanoes are made by the heat inside the earth. The real questions are: Why does that heat behave as it does? and Is that heat made in any special way when the volcanoes are formed? It is certain that, at its very beginning, a volcano is a hole that is burst in the surface of the earth's crust. Once that hole is made we can understand how the heat underneath goes on using it in future; things naturally find their way out through it, because it is the "path of least resistance," and so a pile of stuff is heaped up round it, and a volcano is made.

But the whole earth is hot. Why did the hole, in the first place, form just there? There are, we think, two answers. The first is that probably the earth's crust at these places is thinner or weaker, or made of material that can more easily be pierced; and, also, as we are just learning, possibly special sources of heat and power lie underneath it, owing to the presence of rocks or materials which contain more than their share of the wonderful element radium, or some other heat-producing element like it.

WHY DOES SNOW ON MOUNTAINS MAKE THEM NO HIGHER?

Plainly, something must happen to the snow which falls on such mountains, or they would be bound to get higher, as this question suggests. As new snow falls on the old, the old gets pressed from above, and it tends to slide by its own weight down the mountain.

In this way it gets very tightly squeezed into ice, and though we think of snow as a light thing, yet a mountain-cap of ice, many feet thick, has, of course, a tremendous weight. As it slowly sinks down the mountainside, it makes a bed for itself, just as water does when it runs along the land; and so there is formed a river of ice which we call a glacier. The glacier may run into the sea and form icebergs, or it may melt when it gets low enough upon the mountainside. Some of the snow, but only a small amount, may form into avalanches, and so be disposed of. So we see that the snow that falls on a mountain shares in that endless circulation of water—from sky to earth and sea, and back to sky again—which is certainly going on everywhere.

HOW IS A DELTA MADE?

We must first of all understand what a delta is and why it has that name. If we look at the map of Egypt, we shall find the Nile, which is a very good example of a river with a delta at its mouth, and we shall notice how the river, when it meets the sea, spreads out into a shape something like a triangle. Now, that is the shape of the Greek capital letter D, the name for which is *delta;* and so this shape, made at the mouth of such a river as the Nile, is called its delta.

When a river meets the sea, the water of the river runs into the sea. The tides of the sea also affect the river, and salt water will be found for a certain distance up the river, and also various forms of animal and vegetable life, principally fishes, which live in sea-water. Also, for a certain distance up the river, varying very much in different cases, the height of the river will rise and fall with the tides. We can see this, for instance, in the docks upon the river of any great port.

But a river consists of moving water, and the motion of the water has power to rub away from the bed and from the banks of the river a large quantity of solid material, which is not melted or dissolved in the river-water, but is carried down by it. Now, when the river-water meets the sea its pace slackens, because it is opposed by the weight of the sea-water. Therefore, the solid matter held in the river-water is apt to sink and form a great wide bed or bank of mud. When, as in the case of the Nile, there are two or more main branches, the deposit inclosed by these and the sea takes the form of a triangle. Deltas are nearly always found at the mouths of those rivers flowing into lakes, or inclosed seas, or sheltered gulfs, because there is in all these cases an absence of opposing currents.

HOW IS A CORAL ISLAND MADE?

Over thousands of miles in the Pacific Ocean there are groups of low, ring-shaped islands, and for a long time men have wondered how they were made. We know now that they are actually made of the hard parts of the bodies of countless millions of tiny living creatures belonging to the animal world. The stuff we call coral is really made of the skeletons of these little animals, all joined together. Coral islands have gradually grown upward to the surface from the bottom of the sea, as a result of the life and death of these tiny animals. They only live in water, and so when the coral ring comes to the surface and makes a coral island it stops growing. The tiny animals on the outside of the coral colony get most food, and so grow more quickly and their bodies are piled up faster than those on the inside. So the ring is formed; and often a few cocoanut-trees find a footing upon it, the seeds of the trees being carried to the island by the

wind. We can only guess how many ages it takes for a coral island to grow from the bottom of the ocean till it reaches the surface. Most of what we know about coral islands was found out by Charles Darwin, the greatest man who has ever studied the world of life.

WHY IS THE SNOW WHITE?

We might have asked also why is foam white when a wave breaks. In both cases we know that we are dealing with water, and yet, instead of being transparent, which means that it lets the light through, it is white. We understand at once when we find out what snow and foam are made of, or, rather, what is the state of the water that makes them. In the case of snow, the water is frozen and forms tiny little crystals of beautiful shape.

These all lie loosely together, forming the snow, and though, if you could take one of them by itself, light would go through it just as it will go through a piece of clear ice, or many other crystals, yet when you have a heap of crystals lying together, all turned different ways, they throw the light back in all directions, just as salt does. They do not keep any part of the white light that falls on them, but throw it all back, and so snow is white. But, of course, if you have colored light falling on the snow, then the snow throws back that same color, and this gives some of the most wonderful sunset effects upon snow-covered mountains.

IS WINTER COLD DUE TO THE SUN'S GREATER DISTANCE?

The earth is *not* farthest from the sun in winter; it is then nearest to the sun. But the distance of the earth from the sun has really nothing to do with the weather in any way, and we should get this clearly into our minds. The fact that the earth does not move in a circle round the sun, but in an ellipse, as we know, so that its distance from the sun varies—this fact is enormously important, because the law of gravitation would not be true if the earth moved in a circle. Indeed, Newton measured and discovered gravitation partly by knowing how the earth moves round the sun. But the path of the earth, though not a circle, is very nearly a circle; and the difference in its distance from the sun at different times is far too small to affect the weather. It may be that, long ages ago, the earth's path was much more elliptical than it is now, and then the difference in its distance from the sun may have been very important for the weather—but not now.

WHERE DOES DUST COME FROM?

Dust is matter that has been ground or worn down into tiny separate pieces, like the sand in the desert. If there is much water about, it catches the dust and makes it into mud; and then when the mud dries it is blown into dust again. There can be no dust at all on the moon; nothing is worn down into dust there. The forces that make dust on the earth are air, especially moving air that we call wind, and water. These are, perhaps, helped a little by the power of light. Of course, different kinds of things differ in the ease with which the wind and rain can grind them down into dust, and so we find less dust in some places than others, even though both are equally exposed to wind and rain.

In places where men's feet or wheels of carts and carriages are traveling over and rubbing the ground, much dust is also made by them. That is one reason why cities are so dusty in dry weather. Water-carts lay the dust, because water is heavy, and when a speck of dust is soaked in water, it can scarcely be blown about in the air. In cities, also, much dust is made in the roads by horses, and it is probable that this is very bad for people's throats and eyes. But the most dangerous dust of all is the dust made by the spitting of consumptive people, and this really is one of the principal ways in which consumption is spread. Many people have worked hard for a law to prevent people making this deadly dust, and now in some cities and countries there are laws against spitting in trains, street-cars, and some public places.

WHAT IS THE AIR MADE OF?

The air is a mixture of several gases, and these are all colorless and transparent. Among the gases in the air are carbonic-acid gas, which we give off when we breathe—and which is food for plants—and also a small amount of various other gases only recently found. Most air also contains not a little water in the form of a gas or vapor. But all these taken together do not amount to very much. Very nearly the whole of the air is composed of two gases only; about four-fifths are made by a gas called nitrogen, which is very valuable to plants and therefore to us, and the remaining fifth is made by the wonderful gas, oxygen, by which we live every moment of our lives.

But we should not like to tell you what the air of crowded indoor places is made of, or even what the air is made of that you will find in a bedroom in the morning if only a single person has been sleeping in it all night with closed win-

dows. This air is very different from fresh air or open air. It has the same things in it, but it has a great many other things; it has too much carbonic-acid gas and too little oxygen, and it has all sorts of poisonous gases which the sleeper has given off in his breath and from his skin. But when we ask about air, we mean open air, and we need say no more about foul air except to remember the great difference there is, and that thousands of people are killed every year by not knowing the difference.

WHAT KEEPS THE AIR ROUND THE EARTH?

THERE is nothing whatever but gravitation to keep the air round the earth, and there are many things at work to make the air leave the earth. As the earth sweeps through space in its curved path, every part of it is always tending to move straight on instead of round the sun. And as the earth spins upon itself, the atoms of the air tend to be thrown off like the raindrops from a spinning umbrella. And if the movement of the atoms or molecules of gases in the air becomes quicker than a certain rate, they will fly off into space. There is almost certainly a leakage going on all the time, so that in fact the air is not being completely kept round the earth.

If the earth were smaller, it would not be able to hold round itself so dense an atmosphere as it does, and it would lose its atmosphere more quickly.

This is probably what has happened in the case of Mars, which is older than the earth and smaller, so that it has had more time for its air to leak away, and less power to keep it. So Mars has only a very thin atmosphere. And the moon, which is too small altogether, has now no atmosphere at all around it.

WHY CANNOT WE SEE THE AIR?

THE reason why we cannot see the air is that it is transparent, like glass—that is to say, it lets light go through it. It affects the light in some ways; for instance, light coming to the earth from a star is bent a little as it travels through the air, so that we never see the star where it really is. But directly we change one part of the air as compared with the air around it, so that it bends the light a little more or a little less, then we notice something.

In a sense you can see the air moving sometimes above a hot gas-jet. Also it is quite easy to change air so that you can see it in another way. We can make it cold so that it becomes like water, we can see it as you see water, and we can even freeze it so that it looks and can be seen just like ice. The air, fortunately, has no color in itself, so it does not alter the color of the light passing through it—which would mean altering the color of things seen through it. Some gases have colors, yellow and green and so on, and if they are passed into the other gases which make the air they can be seen; or if you puffed some air into a bright yellow gas you would be able to see the air by contrast.

WHY DOES THE AIR NOT PRESS US FLAT?

THERE are two answers to this question. First, many things have strength enough in themselves to resist a pressure of fifteen pounds to the square inch—which is said to be that of air—without being pressed flat. A piece of steel, for instance, will stand a vastly greater pressure than that. Yet it is true that a great many things, such as our own bodies, for instance, could not possibly stand a pressure of fifteen pounds to the square inch were it not for one thing—the fact that the pressure is on all sides of us. Were it not so, our bodies would certainly be pressed, if not flat, at least very much out of shape. But, as we have seen, the air is a gas—or a mixture of gases, which comes to the same thing in this case—and one of the facts about a gas is that its pressure is the same in all directions. So, while our head is pressed down, yet all the sides of the body are pressed in and together, so that we are not flattened out. Thus, so long as the pressure is the same on all sides, it is, in a sense, as if it were not there.

WHAT IF THE PRESSURE OF THE AIR WERE REMOVED?

SUPPOSE that we find some way of taking a part of the body—say, the arm—and removing the pressure of the air from it altogether, or, at any rate, reducing it very much. Now we shall have unequal pressure on the body, and something is bound to happen. So it certainly does.

Suppose that you had a pain in your arm or in the small of your back. Sometimes the best way of relieving this pain is to take a tumbler, drop a piece of something burning in it, and clap the tumbler on to the skin. You must take care not to burn the body, but that is quite easily avoided if you clap the tumbler on upward instead of downward. Then the air inside the tumbler is largely used up by the piece of burning rag or whatever it is, and the pressure inside the tumbler is very much reduced.

So it is almost as if the little circle of skin

covered by the tumbler had the atmospheric pressure taken away from it, while all the rest of the body went on as before. Now we see what the atmospheric pressure can do. It is pressing on all the body except just that little circle of skin, and so it simply squeezes a lot of the body fluids into that part of the skin, and it swells and swells and rises into the tumbler, until it looks very funny indeed. The air is pressing on every part of the skin except one, and that is the consequence. It does not hurt at all, though it looks as if it should, and it often relieves a deep-seated pain. Then, if you slip something under the edge of the tumbler so as to let the air in, it drops off; and now the air-pressure is equal on all parts of the skin, and the swelling is smoothed out again. This way of relieving pain is called dry cupping.

WHAT MAKES AN ECHO?

Sound is a wave in the air, and anything which will stop that wave and send it back again without altering its shape will make an echo. It is really much the same as the waves of the sea striking against a breakwater and coming back again. If the waves get broken up so that, instead of coming back as they went, they come back irregularly, then you will not hear a distinct echo—just as you will not see your face in a mirror plainly unless it is smooth. So the places where you get the best echoes are places where the sound-waves are thrown back exactly as they came, just as the light-waves are thrown back from a mirror. To make an echo, however, we must be standing far enough away from the wall, or whatever it is that throws the waves back, to give the ear time to hear the sound itself, and then to hear the waves as they come back.

WHERE DOES ALL THE BAD AIR GO?

The answer to this question may teach us a great lesson about the meaning of words like "good" and "bad." It is probably wisest and most reverent for us to believe that in the long run and in their right places all things are good. That, at any rate, is certainly very true of what we call bad air. By bad air we usually mean carbonic-acid gas, which has come from our lungs or from a fire or a lamp, or from the breathing of animals.

We may rightly call such air bad in a sense, because it is bad for us; if there is too much of it in the air any animal is given to breathe, the animal will die. This carbonic-acid gas is moved about by the wind and also by the movement which is natural to its own particles, and so it gets to be distributed very evenly throughout the air. It is very remarkable indeed to find how similar and constant within small limits is the proportion of carbonic-acid gas in the air, wherever and whenever we have the means to examine it.

This gas is of the utmost importance for our lives, even though we rightly call it bad when it is in the wrong place and in the wrong quantity. Without carbonic-acid gas all the green trees and plants would soon die of starvation; then all the animals that live on plants would die; then all the animals that eat vegetarian animals would die; and, lastly, when everything else had died, we should die ourselves.

WHY IS IT COLDER ON A MOUNTAIN-TOP?

You think, perhaps, that as you are nearer to the sun you ought to get hotter. It is true that as we get nearer to the sun we must get hotter, unless something else is working the other way at the same time. But the highest mountain on the earth is not seven miles high, and as no one has ever been to the top of it, and as seven miles is not much worth mentioning, seeing that the sun is more than ninety millions of miles away—well, you cannot expect to gain much by climbing a mountain. For the matter of that, the earth is much nearer to the sun in winter than in summer, but the sun is so far away that that makes little difference.

But now you want to know why you get colder. It is because the warmth that we live by is mostly in the surface of the earth, though doubtless most of it has come from the sun in the first place, and the air, besides being necessary for us to breathe, is also a great blanket that keeps in this warmth. When we climb a mountain we pass through the densest part of this blanket, and pass away from the warm crust of the earth, and so we get cold.

It is just the same when men go up in a balloon. On the other hand, if you go down into a coal-mine you get hot, though if you do so in the daytime you are actually going farther from the sun. We should all be frozen to death in the night if it were not that the earth is warm itself, and that the blanket of air keeps the warmth in for us.

WHY DOES THE WIND BLOW MORE ON THE TOP OF A HILL THAN BELOW?

It is quite true that the wind blows more on the hills than below them, and travelers have reported that when they go to very great heights the wind becomes still more powerful. Where mountaineers have ascended as high as twenty thousand feet or more above the level of the sea, they usually have found a high wind blowing; and

when the mountain is ascended on different occasions, this wind is always found to be blowing, and blowing in the same direction.

People who have gone up great heights in balloons have not noticed the same gale around them as mountaineers have; but that is because the balloon moves with the wind, and so the wind is not noticed, especially if it is a steady wind, and the balloonist at that height cannot always make out whether he is moving or not.

The explanation of all this seems to be that, as the earth moves, and different parts of it get heated in succession by the sun, and also owing to the movement itself, the air at a considerable distance above our heads is constantly moving and forming great winds. Lower down these winds are largely wiped out by the obstacles which the moving air meets on the surface of the earth, and also to some slight extent by friction of the air with the earth, which keeps the air moving in the same direction.

WHY DOES A GALE BLOW TREES OVER AND NOT RUSHES?

Not only rushes, but also some kinds of trees, like the willow, bend before the gale. The reason depends upon the difference in the wood of various trees; some are elastic, and some are not. The tree which is not elastic, but rigid, like the oak, will stand unmoved, so far as its trunk is concerned, in a very strong wind, though far less wind will make the rush or the willow bend, because it is nothing like so strong. But if the wind becomes a great gale the oak will break; the willow and the rush will bend as they did in much less wind, and when the gale is over they will come upright again because they are elastic. If you strike a piece of string with a stick it will bend, but will not break; if you strike a thin stick with a thicker stick the thin stick will break. That is what happens in a gale of wind.

There is a very good lesson for us here. There are people who are like the oak; they are strong and can stand a great deal, but they are rigid, and do not know when to yield or give in, and the time will come when they will, so to speak, break; while other people who are less strong will recover. But the wisest people and the strongest have the advantage of either the oak or the rush, for they can be strong as the oak when it is necessary, and can give in gracefully when that is necessary. Many great men in history were like this, but many bent and gave in to save themselves, even at the cost of their honor, when it would have been nobler to break altogether, even though that meant losing all their power.

WHERE ARE THE CLOUDS WHEN THE SKY IS QUITE CLEAR?

Clouds, as we know, are made of water, and water can exist in the air in many different forms. When it forms a cloud, it is really in the form of liquid drops, like the collection of drops that forms a cloud from our breath on a frosty day.

The water that formed the clouds is still in the sky when it is cloudless. What has happened, however, is that, partly owing to the warmth of the sun, and partly, no doubt, to electrical conditions in the upper air, the air is capable of holding all the water in it in gaseous form.

This gaseous water, or water-vapor, is just as transparent as air itself; indeed, it is much better for us to regard water-vapor as one of the things that make up the air, just as much as oxygen or nitrogen. It is difficult for us to realize, perhaps, when we look up at the sky on a cloudless day, that we are looking through water, but we are certainly doing so just as if we had our eyes open under water and were looking up. If it were not for the water that forms part of the air, we should be utterly scorched by the heat of the sun. As it is, however, most of the sun's heat is caught by the water-vapor, which is very opaque to heat, though it is very transparent to light.

WHAT IS IT LIKE ABOVE THE CLOUDS?

When we go up in a balloon above the clouds, or when we go so high up a mountain that we leave the clouds beneath us, we find exactly what we expect. The air is very bright and clear, and the sun—or the stars, if it is night—are seen very distinctly. Both sides of a cloud are very much the same, and when we look down on the clouds from above, they appear just the same as bright clouds appear from the earth. They are, of course, always bright clouds that we see from above, because we are looking at the side of them upon which the sun is shining. We find much the same thing if we go up in a balloon through a heavy fog.

Some astronomers who did this found that at a height of several thousand feet the balloon soared clear of fog, and came out into brilliant sunshine. They saw the fog beneath them, but, of course, they saw it as a quite bright thing, as a great deal of the sunlight which should have been pouring down upon the earth was stopped by it, and reflected back from its surface to their eyes. When there is no fog, but only clouds scattered about, and we go up above them in a balloon, we get glimpses of the earth between them as we look down; and those who have seen this say that it is a very wonderful sight. Of course,

they do not see the earth spinning underneath them, because the air spins round with the earth, and the balloon spins round with the air.

WHAT IS THE SUN MADE OF?

Not very many years have passed since it was said that this was a question to which no answer could be made. At that time no one had guessed the wonderful fact that, by holding up a prism to sunlight, and noting what the light looked like after it had come through the prism, we should be able to tell exactly and positively what chemical elements must be in the sun at the places where the light has come from.

Of course, it might be that when the light was studied in this way it gave us evidence of the presence in the sun of certain things quite different from the elements we know upon the earth. But the great and never-to-be-forgotten fact is that what we find is clear evidence that the sun is made of the same familiar elements that go to make up the earth and our own bodies—elements like carbon, oxygen, hydrogen, magnesium, calcium, and iron, besides many others.

WHY DOES SMOKE ALWAYS COME FROM A FIRE?

There is no real reason why smoke should always come from a fire, and already there are many ways of making fires which produce no smoke. The time is not very far off, perhaps, when no one will be allowed to make fires that produce smoke. The reason why smoke comes from our ordinary fires is the same as the reason for a great many other facts that we can notice. It is, indeed, the reason which explains the making of the coal in the first place. Carbon will not burn unless it is hot enough, and it is less easily burned than most of the other things that can burn. So a certain quantity of carbon is apt to go unburned, though this will happen far less if we keep the fire hot enough, which is to be done by giving it a good supply of air. If we make a forced draft, and keep up a steady, quick flow of fresh air—that is to say, of fresh oxygen—to the fire, then we shall find that all the carbon is burned up, and no smoke will be produced. Smoke is always a sign of failure and waste, even if there were nothing worse to say about its consequences.

DOES A FALLING STONE DROP FASTER AND FASTER?

Yes: if falling things did not fall quicker as they fell, it would hurt us no more to fall five hundred feet off some cliff, or to fall thousands of feet from a balloon, than to fall to the ground when playing a game. The farther a thing falls, the more quickly is it moving when it reaches the ground, and the greater is the force with which it strikes the ground. If there were nothing to resist the fall of objects, there would be nothing to prevent this increase in speed getting greater and greater; but there is always the resistance of the air, and in the case of the fall of rain-drops, that is sufficient to hold them back. If it were not for this, a rain-drop falling on our head might fall with such terrible force as to kill us. The proper name for the increasing speed of a falling body is *acceleration,* and we shall remember not to spell it with two l's if we know that it comes from the Latin celer, *swift.* The acceleration due to the pull of the earth, which we call gravity, is the same for all falling bodies. It is not greater for a heavier thing than for a lighter. Galileo showed this when he dropped two balls, one light and one heavy, from the Leaning Tower of Pisa, and they reached the earth at the same moment. The amount of this acceleration has been precisely measured. It is 32 feet in every second of time—that is to say, the falling body in each second falls 32 feet more than it did in the second before.

HOW FAR DOES A STONE FALL IN THE FIRST SECOND?

We know exactly the answer to this question. We might think at first, if we read the answer to the last question, that the stone must fall 32 feet. But 32 feet is the amount of increase in the rate of its falling at the end of a second, and at the beginning of the second the stone was not moving at all. Therefore, its average rate of movement throughout the second is midway between no movement at all and 32 feet—in other words, an average of 16 feet per second. That is what we find; at the end of a second the stone has fallen 16 feet.

WHY DOES A STICK FLOAT?

We must remember that the earth is all the time trying to pull everything to itself; it pulls us, it pulls the air, it pulls a balloon, it pulls the moon. Now, the heavier the thing is the more it is pulled, and water is heavier than a stick. This does not mean that all the water in a pond is heavier than a stick, because, of course, we know that. But it means that, if you had a cup and filled it with water, and had another cup the same size and filled it with stick, the cup with the water would be heavier—that is to say, in a fixed amount of space you can pack a greater weight

of water than of wood. That is what we mean when we say that the water is heavier than the stick.

Of course, a pound of water is the same as a pound of stick, and you do not need me to answer the question—Which is the heavier, a pound of feathers or a pound of lead? They both weigh the same, only the lead takes up less room, and so we say that lead is heavier than feathers, though a pound of lead weighs the same as a pound of feathers. The proper name for a heavy thing is *dense,* and, whenever it is possible, the earth always pulls the denser things farthest down, and the less dense things are nearer the top. That is why the stick floats; that is why the cold air is found nearest the floor, because cold air is heavier, or denser, than warm air, and the warm air floats on the top of it as the stick floats on water.

HOW DOES A BALLOON KEEP UP?

This question is really the same in its explanation as the question why does a stick float. We must remember again that the air is a real thing. If there were no air, the balloon would drop like a stone, just as, if the water all disappeared from the sea, the fishes would drop to the bottom. Things float in the sea, or on the surface of it, because the amount of stuff in the space they occupy is less than the amount of stuff in the same space of water. Again it is a question of density. If you pour hot and cold water into a bath or into a tumbler, the hot water will lie at the top and the cold at the bottom, because water is less dense, and therefore less heavy, when it is hot than when it is cold. Gases behave in exactly the same way. Hot air behaves in the midst of cold air just as hot water behaves with cold water—it goes upward.

Now, if you put the hot air into something very light, the hot air, as it goes upward, will take that something with it. The first balloons were made on this principle. Two Frenchmen, the brothers Montgolfier, made balloons of silk and linen and filled them with hot air and smoke, and after making balloons which carried animals, they persuaded some men to be carried in this way. You understand that this was simply because hot air is less dense than cold air, and therefore lighter.

CAN A BALLOON GO BEYOND THE GRAVITY OF THE EARTH?

Certainly a balloon could not pass beyond the gravity of the earth, because the balloon floats in the air, and, as it goes up, the air becomes thinner and thinner, until at last it is too thin to support the balloon, and the balloon can go no higher. If anything is to pass beyond the gravity of the earth, and escape from the earth, it must have some motion in itself sufficient to carry it so far that the earth cannot pull it back again.

This must have happened to the stuff which makes the moon when it was thrown off from the earth. It used to be thought that some or all of the iron and other meteorites which are sometimes caught in the air—and which we call shooting stars—might really have been formed in the earth. This was thought because these things were found to be made of the same stuff as the earth, at a time when we did not know that all the universe is made of the same kinds of stuff. It was supposed that volcanoes might have shot up stones and so on with such force that they passed right through the air, and left the earth altogether, and then happened to be caught by it again at some later date.

We do not think that now. It is very probable, however, that certain very light gases, which—because they are light—seem to exist mainly in the upper layers of the air, may escape from the earth altogether, perhaps being thrown off from the air as drops are from a twisting umbrella. That seems to be the reason why the moon has no air, since the moon is very small, and has not strength of gravity enough to keep a gaseous envelope, such as our air is.

IS THE EARTH GETTING SMALLER?

Yes: but we must understand what we mean by smaller; we mean actually smaller, and not less heavy, for that is another question. The earth might get smaller by shrinking without losing any of the stuff which makes it, or it might get smaller because part of the material of which it is made has been lost. It might shrink smaller, or it might wear smaller, so to speak.

We are certain that the earth is shrinking smaller, because we know that it is slowly losing heat and getting colder, and if it does this it is bound to shrink. We suppose that the great cause of earthquakes is the shrinking of the inside of the earth as it cools, so that the crust on which we live is left not sufficiently supported.

As regards the possibility that the earth is wearing smaller, we cannot doubt that it does slowly lose a certain amount of the gases of the atmosphere by a sort of leakage from the outside layers. But, on the other hand, certain things reach the earth and add to its amount from outside space; and, for all we know, the earth may be actually gaining more in this way than it loses in the other way.

It has been known for many years that the earth lives in a more or less constant shower of meteors, and these become part of the earth when they reach it. That is true whether they reach the solid earth or whether they are burned up completely in the air. Also, we now believe that the sun is always shooting out tiny particles of atoms, called electrons, in all directions, and our earth catches a vast number of these.

IF ALL THINGS BORN LIVED, COULD THEY BE SUSTAINED?

The answer is certainly No. The average number of fishes in the sea is generally the same, yet one female fish may produce a million eggs—of which only one or two will live. A single microbe, if there were food enough, would multiply into millions in a few hours. Rabbits introduced into a country like Australia, where there happens to be a lot of food for them, become a pest in a few years. Every kind of plant and animal, high or low, tends to multiply far too rapidly. And when we look closely at the facts we find that the very reason why practically everything that is born does not live is simply that the earth cannot sustain them all. The struggle for life that goes on without ceasing among all creatures is a struggle for the food-supply; and there is always a much smaller food-supply than is needed for the quantity of young life that is always competing for it.

We may wonder that Nature should bring so many more mouths into the world than she is able to feed, but we are beginning to see that there are good reasons for this terrible waste, as it seems to be. At any rate, among human beings a much larger proportion of young creatures find room and food on the earth than among any other kind of living beings.

WILL OUR WORLD EVER BURN OUT LIKE THE MOON?

There can be no doubt about the answer to this question, though no one can tell how long it will take before the answer is fulfilled. Our earth must become like the moon. There will be certain differences, because the earth is much larger than the moon. The moon has been too small to hold to itself the gases outside it. It has no air or atmosphere. The earth is able to keep its atmosphere because it is bigger, and so the power of its attraction is much greater. Such reasons as this will always make a difference between the earth and the moon.

Another difference is that, in consequence of the rapid cooling of the moon, the changes on its surface have been more violent than those on the earth. The biggest volcano on the earth is nothing compared with those of the moon. But all these points of difference do not affect the fact that our earth is bound some day, though after a far longer time than men lately thought, to become cold and lifeless like the moon.

CAN THE WORLD GO ON IN ITS PRESENT FORM FOREVER?

We are certain that, unless the sun should rush into another star, and make so much heat as to burn us all up—which is very unlikely—the earth will go on much as it is now for many ages to come; yet slow changes are always going on, and going on *in one direction,* that must lead to great results some day. The earth *must* be either getting cooler, or else using up the radium that keeps it warm; it is bound to become cold some day, as is the sun itself. That day may be far off—farther off than we are now from the time when the earth was formed—but it must come some time. Then there is evidence to show that the motion of the earth must be getting slower—though very slowly; and probably at last the earth will be drawn into the sun, and so end its independent history. Recent discoveries have made us form longer estimates of the time that these changes will take to happen; but it seems certain that they must happen some day.

ARE THERE ANY PEOPLE IN THE OTHER WORLDS?

This is a great question, to which no one can return a certain answer, and about which many big books have already been written and many more will be written. But something we can be sure of. People sometimes talk as if there could be *men* on other worlds, but we may be sure, when we think of the wonderful way in which men are adapted to this earth of ours, to its air, and water, and climates, and food-supply, that there could be men like ourselves only on a world *just like ours.* The other worlds that we know all differ greatly from our earth in all sorts of most important things, such as the composition of the air. *Man,* then, is a child of earth—this particular earth of ours; he is exquisitely fitted for it, and it for him, not only in its air, and soil, and oceans, and heat, but also in the kind, and the balance, as we may say, of the thousands of animals and plants that inhabit it with him. We are certain that men and women and children like ourselves could be found only here or, as we have said, on some other world which is an exact double of our earth, and we do not know of the existence of any such world.

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